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SPENCER F. BAIRD

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PREFACE.

The present volume is the seventh of a series commenced in 1871, and which, although entirely unconnected with a work having somewhat the same object—the Annual of Scientific Discovery—took up the record of scientific and industrial progress where the latter left it off, after having been published since 1850. The two therefore form a continuous history of the subject for twenty-seven years.

Heretofore the "Annual Record" has for the most part been composed, first, of a summary of scientific progress during the year; and, second, of a series of abstracts of the more important articles contained in the proceedings of learned societies and in the scientific and industrial journals of the day. With the rapid increase in the number of such papers, it has been found impossible to compress the abstracts in the limits necessarily assigned to the annual volume; and it has therefore been concluded to omit them entirely, and, by an extension of the Summaries, to furnish what will probably better answer the purposes of the student.

A minute alphabetical index will supply the means of ready reference to the more important data. The names of the several gentlemen whose assistance has been obtained in the preparation of the series of summaries will be sufficient guarantee of the completeness of their work.

As in the earlier volumes, there will be found a list of the principal losses to science by death, and a bibliography of the more important publications, whether in the form of books or of scientific memoirs. The latter, as heretofore, has been prepared with the assistance of Professor Gill, of Washington.

SPENCER F. BAIRD.

SMITHSONIAN INSTITUTION, WASHINGTON, *March* 1, 1878.

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ANNUAL RECORD

OF

SCIENCE AND INDUSTRY.

1877.

ASTRONOMY.

By EDWARD S. HOLDEN,
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INTRODUCTION.

THE year 1877 will be remembered by the discovery of the two faint satellites of *Mars* more than by any other one event. A possible satellite of *Mars* has often been sought for by D'Arrest, Tuttle, and others, but an imagined analogy placed such a satellite or satellites farther from the planet than either of the bodies discovered by Professor Hall. These satellites may be said to be fatal to the analogies ordinarily quoted, and to show how vague a guide these really are. The outer satellite is almost unique in the solar system, and the inner one is quite so, in its relations of distance and mass with its primary. A further account of these will be found in the proper place.

The changes of spectrum of Schmidt's *Nova Cygni* are of great importance, and are certainly not yet understood; and the same may be said of Dr. Henry Draper's discovery of oxygen in the sun, even the nearer consequences of which have not yet been worked out.

The astronomical expedition of Mr. David Gill to Ascension Island is particularly noteworthy; and by advices from Mr. Gill up to October 8, it appears probable that success is secured. These and other subjects are spoken of briefly under their appropriate heads, but it must be remembered that the accounts here given are necessarily the barest summaries, and are intended mainly to call attention to work which has been done, in order that a reference to the originals may be made when desired.

NEBULÆ AND THE NEBULAR HYPOTHESIS.

Lord Rosse is preparing for publication all the observations of nebulæ made at Birr Castle with his six and three feet mirrors during the last thirty years. Those drawings which have already been published in the *Philosophical Transactions* will not be republished. The whole will probably be divided into three or four parts, each comprising 6 h. or 8 h. of right ascension. The editing is done by Dr. Dreyer, Lord Rosse's assistant, and the work is to be published by the Royal Irish Academy. It is expected to be soon in the hands of astronomers.

Dr. Dreyer is also engaged in preparing a supplement to Herschel's general catalogue of nebulæ, etc., and any additions or corrections to this should be sent to him.

The Melbourne reflector has for some time been employed for the purpose of re-drawing all nebulæ previously figured by Sir John Herschel. Forty-nine nebulæ have been carefully drawn by the observers, and the results of the work are about to be published. Mr. Ellery speaks of the lithographic copies of these drawings as fully successful.

M. Stephan, of Marseilles, gives the places of thirty new nebulæ discovered by him, making 185 in all found at Marseilles. The first 125 of these will appear in Dreyer's new catalogue of nebulæ.

Dr. Koch, of the Leipzig Observatory, has published a micrometric investigation of the cluster G. C. 1712 for his inaugural dissertation. It contains an interesting *résumé* of previous work of this kind. Other work of the kind is now in hand at this observatory.

The cluster *Gamma Argûs*, respecting which Gilliss reported changes since Sir John Herschel's observations, has

been photographed several times by Gould at Cordoba; and Dr. Gould also reports that he has eight plates of *Eta Argûs* and surrounding stars, of which a very large number is secured upon the photograph by an exposure of from eight to ten minutes.

Dr. Valentiner, at Mannheim, has begun the investigation of several star clusters, and such investigations are to be continued as a principal work of this observatory.

At Kiel, Peters continues observations of nebulæ for position, which were undertaken at Altona.

Dr. Schmidt, of Athens, has just published in the *Astronomische Nachrichten* a suggestive paper on the connection of the nebula h. 3770 with variable stars in the vicinity. His facts seem to indicate a relation between them.

M. Tempel, of Florence, sends to the *Astronomische Nachrichten*, No. 2138, a long account of his observations of nebulæ at Florence, which are prosecuted under many difficulties, and gives some account of the great variations which he has found to exist between drawings of the same nebula by various observers.

Professor Holden has a paper in *Silliman's Journal* on the proper motion of the *Trifid Nebula*.

From the older observations of the two Herschels it follows that—

1. *From* 1784, *July* 12, *to* 1833, *the triple star* Sh. 379 *was centrally situated between the three nebulosities.*

Again, from the later observations of Mason, Herschel, Lassell, Langley, Trouvelot, and Holden, it follows that—

2. *From* 1839 *to* 1877 *the triple star was not centrally situated between the three nebulosities, but involved in* A.

It is shown that each of these propositions rests on a firm basis. Granted that 1 and 2 are correct, there are but three ways to reconcile the opposing facts:

a. The triple star has a large proper motion.

b. The nebula has a large proper motion.

c. The nebula is subject to decided changes of brilliancy.

The first point will be settled by meridian observations now in progress. The relative positions of the various stars of the group seem to have been unchanged since 1839. If, as is probable, the proper motion of the triple star is small, there remain the two alternatives *b* and *c* to choose between.

Mr. Plummer has a note on the collective light distribution of the fixed stars. He finds that fully three fourths of the light of a fine night comes from stars which are individually invisible to the naked eye, and that on his hypothesis the total light of all the stars of the *Durchmusterung* is equal to 10.17 × Venus at maximum brilliancy, or 1 ÷ 78.6 of the mean full moon. His final conclusion is that "either the *Durchmusterung* contains many stars (more than one third of the entire number) which, though rated as 9.5 magnitude, are sensibly below it, or else it must be assumed that at the average distance for stars of this magnitude a denser stratum actually exists, succeeded possibly by regions less fruitful beyond."

NEW STARS.

"Schmidt's observations of the new star of 1866 (*T Coronæ*), continued up to the present time, show that after falling from the second to the seventh magnitude in nine days, its light diminished very gradually year after year down to nearly the tenth magnitude, at which it has remained pretty constant for the last two years. But during the whole period there have been fluctuations of brightness at tolerably regular intervals of ninety-four days, though of successively decreasing extent. After the first sudden fall, there seems to have been an increase of brilliancy which brought the star above the seventh magnitude again, in October, 1866, an increase of a full magnitude; but since that time the changes have been much smaller, and are now but little more than a tenth of a magnitude. The color of the star has shown no change from pale yellow throughout the whole course of observations."

Lord Lindsay makes the important announcement that Schmidt's *Nova Cygni* (R. A. $21^h\ 36^m\ 52^s$, Dec. $+41°\ 16'\ 53''$), which blazed forth suddenly last November, exhibiting a continuous spectrum with numerous bright lines, now gives monochromatic light, the spectrum consisting of a single bright line, corresponding in position to the characteristic line of gaseous nebulæ. From this fact Lord Lindsay infers that this star, which has now fallen to 10.5 magnitude, has actually become a planetary nebula, affording an instance of a remarkable reversal of the process imagined by Laplace in his nebular theory.

Lord Lindsay's discovery is, according to Mr. Christie, of Greenwich, "confirmed by an examination of drawings of the spectrum of this star at five epochs between 1876, Dec. 8, and 1877, March 2, given by Dr. Vogel in a paper summarizing his own observations as well as those of other observers. Though in themselves these are not sufficient to indicate the conversion to a nebula, they acquire great importance in the light of the Dun-Echt observation, for they show clearly the progressive fading out, not only of the continuous spectrum, but also of the hydrogen and other bright lines."

This new star in *Cygnus* has been the subject of observation by Cornu, Copeland, and Vogel by means of the spectroscope; and from all the observations it is plain that the hydrogen lines at first prominent have gradually faded. With the decrease in their brilliancy, a line corresponding in position with the brightest of the lines of a nebula has strengthened. On December 8, 1876, this last line was much fainter than F, while on March 2, F was very much the fainter of the two. Lockyer, in commenting upon these facts, says that it has been shown by Croll that if the incandescence of this star came from the collision of two bodies, each having half the mass of our sun, and moving 476 miles per second, enough light and heat would be produced to cover the sun's radiation (at the present rate) for 50,000,000 years. As so much light, etc., has not been produced, Lockyer argues that this body "might weigh only a few tons or even hundred-weights," and that it may therefore be quite near to us, and he suggests that accurate observations for position may indicate a motion.

Mr. S. C. Chandler, of New York, gives in the *Astronomische Nachrichten*, No. 2119, the results of his observations in 1875 on twenty-five variable stars. Anomalies have been detected in the light curve of *R. Sagittæ* which point out the necessity of further examination. This series is noteworthy as being the only one made in the United States (we believe) since Masterman's, published in Gould's *Astronomical Journal.*

Dr. Schmidt, of Athens, communicates to the *Astronomische Nachrichten* a long series of variable star observations made in 1876.

A new work of 113 pages quarto on the photometry of the fixed stars, by Wolff, is published at Leipzig.

Klein, of Cologne, formerly announced that *Alpha Ursæ Majoris* periodically changed color from an intense fiery red to a yellow or yellowish-red every five weeks. Weber, of Peckeloh, has observed this star during August, September, October, and part of November, 1876, and finds this period to be about thirty-five days, as before. This periodic change of color must, then, be admitted, and it is the first one which rests on a sure basis, and which regularly recurs at short intervals.

Pogson's catalogue and maps of variable stars are referred to under the head of star catalogues.

Montigny, in the *Bulletin* of the Belgian Academy, 1876, No. 8, publishes an elaborate discussion on the scintillation of stars.

Dr. Schmidt, of Athens, publishes in *Astronomische Nachrichten*, 2109, an important paper on meteors, which comprises the results of a thirty-four years' series of observations.

P. Secchi has drawn up a list of 444 stars of marked color, giving their positions for 1870, as well as magnitudes and notes on the color. "This is a considerable enlargement of Schjellerup's Catalogue, which contains 280 red stars; but that it is very far indeed from being exhaustive is shown by the circumstance that M. Fearnley, at Christiania, has noted no fewer than thirty-four such objects in observing a zone of about 5°. In fact, it would seem that the comparative rarity of red stars in catalogues is simply due to the observer's attention not having been directed to this point; and there can be little doubt that a large number of stars of the sixth magnitude and under will be found on careful examination to be decidedly red."

DOUBLE, MULTIPLE, AND BINARY STARS.

A general catalogue of double stars is now printing which will probably be found to fulfil all the conditions for a work of this class. It is from the hands of Mr. Burnham, of Chicago, and is the work of many years. It will contain all the elements of position (for 1880) with the particulars concerning each star from the latest trustworthy authority, and

copious notes referring to previous measures. For important stars the entire history is given or rendered accessible, a special treatment having been adopted for binaries. It is to be printed as an Appendix to the Washington Astronomical Observations for 1876, and will be eagerly looked forward to by all to whom such a work is a daily need.

The Observatory at Cincinnati has begun its work, since its removal to its new site, by researches in this field. The former observations of Mitchell have been reduced and published, and also a series of measures of double stars of southern declination. It is announced by the director, Professor Stone, that it is the plan of the Observatory to observe the doubles lying in the zone between 15° and 35° S. The great number of measures made by Otto v. Struve, at Pulkova, have been reduced and printed, but no copy has yet reached the United States. Recent measures of a large number of Struve's doubles are, however, available in the work of Dunér, of Lund. This includes 2679 observations made in the nine years from 1867 to 1875. Measures of many of the doubles, arranged in chronological order, accompanied by a tolerably full discussion of the whole series of observations, from Herschel's to Dunér's, are given. A table is added in which the stars are arranged in classes according to the arc through which they have moved since the earliest observation.

Class I. contains those stars which have moved through a complete revolution, and comprises 8 stars.

Class II., those stars which have moved through 180° of their apparent orbit—8 stars.

Class III., those which have moved through 90°—8 stars.

Class IV., those which have moved through 30°—16 stars.

Class V., those which have moved through 10°—48 stars.

Class VI., those which certainly have an orbital motion—59 stars, etc., etc. So that there are 147 stars in this list which have been proved to be binary in character.

The recent measures of Dembowski, Ferrari, Schiaparelli, Wilson and Seabroke, Hall, Newcomb, Gledhill, and others are noteworthy, as well as the theoretical researches of Doberck on binaries, but they are too numerous to be referred to in detail.

The work of Lord Lindsay ("Publications of the Dun-Echt Observatory," vol. i.) is intended to supply the place of a gen-

eral catalogue so far as the double stars of W. Struve are concerned. It is a careful collection of all the measures of Struve in the "Mensuræ Micrometricæ," and in the minor works, and all these stars (above 3000 in number) are arranged in order of their right ascensions for 1875.0. For each pair all the particulars of magnitude, color, distance, position-angle, date of observation, even the magnifying powers employed, are given, as well as the co-ordinates, right ascension and declination for 1875. The precessions are to be taken from a table appended to the book. The full notes give further measures. Thus the particulars regarding each star are to be found collected on one line. If a reference to Struve's own measures is desired, a column gives the page of the original work where these may be found.

Flammarion, of Paris, has in the press a work on binary stars, etc., in which all observations are given for each star, and a discussion of their orbits, etc., follows.

Burnham, of Chicago, has lately discovered some interesting doubles, among which we may cite L 22020, $p=60°\pm$, $s=0.5''$, mags. 9, 9; *O. Arg.* 11836, $p=80°$, $s=1''\pm$, mags. 8, 9; L 18231, $p=70°$, $s=1.3''$, mags. 8.5, 10. These are remarkably difficult stars to be found with a six-inch aperture. Mr. Burnham also notes that 8 *Sextantis*=A. C. 5 is a *rapid* binary, having moved 130° since 1860.

It may be definitely stated that the new companions to *Polaris* reported by Boë do not exist, as Mr. Burnham, of Chicago, has examined this neighborhood with the 18-inch refractor at Chicago without finding them.

Struve and Dubiago, of Pulkova, publish in the St. Petersburg Academy *Bulletin* a new investigation of the orbit of Σ 1728=42 *Comæ Berenices.* The orbit is based on thirty-eight measured distances alone (the apparent orbit being strictly a right line), and the observations are represented with unusual exactness. The period is 25.71±0.080 years. This orbit must be regarded as better established than that of any binary.

Gruber, of Buda-Pesth, gives the following elements for *Eta Cassiopeiæ:* Periastron passage, 1706.72; periodic time, 195.235 years; eccentricity, 0.6244; longitude of node, 33° 20′, of periastron, 229° 27′; inclination, 48° 18′ (1850.0). These

elements satisfy the normal places well: $a=8.639''$, and Struve has found the parallax $0.154''$; mass of the system, 4.63, that of the sun being 1, and $a=56.10$, the earth's mean distance being 1.

STAR CATALOGUES AND MAPS.

The progress made in the zones of the *Astronomische Gesellschaft* cannot be definitely stated until after the publication of the report of their meeting at Stockholm. The "Durchmusterung des Nördlichen Gestirnten Himmels," the joint work of Argelander and his assistants, Krüger and Schönfeld, embraces all the stars of the first nine magnitudes from the North Pole to 2° of south declination. This work was begun in 1852, and at its completion a catalogue of the approximate places of no less than 324,198 stars, with a series of excellent star-maps giving the aspect of the northern heavens for 1855, was at the service of astronomers, and has been in the most constant use from that time forward. Argelander's original plan was to carry this *Durchmusterung* as far as 23° south, so that every star visible in a small comet-seeker should be registered. His original plan was abandoned, but his former assistant and present successor at the Observatory of Bonn, Dr. Schönfeld, is now engaged in executing this important work. The same methods will be followed by Schönfeld which were so successful formerly; the equinox of 1855 is chosen as the fundamental one; and almost the only changes are the adoption of a telescope of six inches aperture for the work, and a closer discrimination of the magnitudes of the fainter order of stars. In the prosecution of the plan, Schönfeld has already determined the position of 74,885 stars; and astronomers in the northern hemisphere will soon possess an index, as it were, to every star likely to be used in their observations.

The last report of the National Observatory of the Argentine Republic is dated March, 1876. Dr. Gould reports that the Uranometry is ready for the press, except the text. The *Zones*, which were begun September 9, 1872, were finished August 9, 1875, and contain over 105,000 stars, and comprise the region from —22° 50′ to —88° 10′. The *Standard Catalogue* now contains 4253 stars (12,661 observations), besides 54 circumpolars (1461 observations),

and the time stars (1684 observations). The observations for the catalogue will terminate in 1877.

From a letter of Dr. Gould's we learn that the reductions of these zones are in a forward state. All observations are reduced to the middle of the field in both co-ordinates in duplicate. The reduction to 1875.0 is completed for 700 zones out of the 754; Δt, c, and n are computed for all the zones and two thirds of the refractions are completed. In February the work of printing the first meteorological volume commenced.

The maps of the Uranometry of the Southern Heavens, made by Gould and his assistants at Cordoba, are now preparing at Bien and Co.'s in New York. They are to be lithographed, and each map will be about half the size of the maps to the *Durchmusterung.*

From the annual report of the Astronomer Royal to the Board of Visitors we learn that the new nine-year catalogue is well under way, and that Sir George Airy will publish his numerical lunar theory as an appendix to the Greenwich volume.

The Paris Observatory continues the publication of ecliptic charts compiled from observations of MM. Henry.

Houzeau, of Brussels, has presented to the Belgian Academy a Uranometry of nearly 6000 naked-eye stars, which was constructed by him during a residence of thirteen months in the West Indies. It is presumed that this work will shortly be published.

The Cape of Good Hope Observatory has published a volume which contains the mean positions of 1246 stars, including all of Lacaille's stars in the "Cœlum Australe Stelliferum," which now fall between 155° and 165° N. P. D., and some additional ones in the same zone. Lacaille's stars between 145° and 155° N. P. D. were similarly observed in 1875, and those between 135° and 145° in 1876. We shall soon, therefore, have accurate places of all Lacaille's stars.

"Although the observations of the moon, planets, and comets made at Kremsmünster have been published from time to time, no publication of the results for stars has taken place, with the exception of a catalogue of 208 stars, printed in the *Memoirs* R. A. S., vol. xii. Reslhuber, however, reduced the observations of 560 stars to the epoch 1840; and

in order that this labor should not be altogether in vain, Herr Strasser, the present director, has incorporated with them his recent results for the period 1864–1874. He has thus formed a catalogue of 750 stars, all reduced to the epoch 1870, the two sets of observations being combined in case of agreement between the results."

Mr. Pogson, of Madras, has about 29,000 unpublished meridian observations of about 3000 southern stars, from which a catalogue is to be compiled and published. He is also making a complete atlas of telescopic variable stars in 136 maps, containing the approximate positions of over 40,000 stars.

Dr. Gyldén, director of the Observatory of Stockholm, has published the first part of Vol. I. of the annals of that observatory. It contains the observations of right ascensions made at Stockholm during 1874, and a catalogue of the mean right ascensions of these stars for 1875.0. Part second will contain the north polar distances; part third will contain tables of elliptic functions of use in the calculation of the perturbations of comets.

Professor Safford, of Williams College, has prepared for the use of the United States Engineer Department Survey under Lieutenant Wheeler a catalogue of the declinations of 2018 stars, which is now passing through the press.

The catalogue of standard declinations, prepared by Professor Boss, of Albany, is now being printed.

Dr. Loewy, of Paris, has presented to the French Academy of Sciences a catalogue of 521 moon-culminating stars. The places of these depend upon observations made at the Observatory of the Bureau of Longitudes with portable instruments. The bureau has just completed the determination of the telegraphic longitudes of Neuchâtel, Geneva, and Lyons. It will shortly undertake the determination of the longitude of Lisbon. Knobel's important work on the Chronology of Star Catalogues is mentioned under Bibliography.

THE SUN.

In a paper published in the *American Journal of Science and Arts*, Dr. Henry Draper, of New York City, announces the discovery, by means of spectroscopic photography, of Oxygen in the solar atmosphere; and he brings the evidence

to the eye by printing from his original negatives the juxtaposed spectra of the sun and of the gas. In the photograph can be seen each bright line of the oxygen spectrum matched and prolonged by a corresponding bright line in the spectrum of the sun.

"While the metallic elements reveal themselves by *dark* lines in the solar spectrum, oxygen shows *bright*, and this is probably the reason why it has so long remained concealed; for these bright lines or bands which indicate its presence are inconspicuous and easily mistaken for mere unoccupied intervals between the multitudinous dark lines which abound in the portion of the spectrum where they are found. The attempt has always been to identify some of the dark lines of the solar spectrum with those of the element in question, and the bright bands escaped investigation until the photograph brought out their significance. Why oxygen should behave thus differently from the other substances before detected it is not yet possible to say with certainty. A possible explanation is that its very abundance has hidden it. A gaseous substance, sparingly present in the solar atmosphere, would declare itself by faint dark lines in the solar spectrum; but if the quantity of the gas should be gradually and continuously increased, these dark lines, after growing for a time more intense, would then by degrees fade away, and when the quantity of the gas had become sufficiently great, would be replaced by bright ones. But on this hypothesis it is very difficult to understand why oxygen is not conspicuous in the chromosphere; like the substance which gives the so-called D^3 line, brilliant in the chromosphere spectrum, but invisible (usually) in the spectrum of the sun's surface. Probably the full explanation lies somewhat deeper."

Professor Langley, of Pittsburgh, publishes in the *Monthly Notices*, R. A. S., a paper on the measurement of the direct effect of sun-spots on terrestrial temperature. It is not intended to show that the earth is, on the whole, cooler in maximum sun-spot years, as the discussions on the paper (as reported in the *Astronomical Register*) indicate it to have been misinterpreted to mean. The observations consisted in measuring the relative amounts of umbral, penumbral, and photospheric radiation. The relative umbral, penumbral,

and photospheric areas were deduced from the Kew observations of spots; and from a consideration of these data, and confining the question strictly to changes of terrestrial temperature due to this cause alone, Langley deduces the result that "sun-spots do exercise a direct effect on terrestrial temperature by decreasing the mean temperature of the earth at their maximum." This change is, however, very small, as "it is represented by a change in the mean temperature of our globe in eleven years not *greater* than 0.3° C., and not *less* than 0.05° C."

Professor Langley has also had constructed an apparatus, which is similar in principle to one devised by Dr. Hastings. It consists of two prisms by which two spectra from various parts of the sun can be juxtaposed. Comparing the light from the two limbs, for example, one is enabled to discriminate the atmospheric lines, and the proof of solar rotation and a measure of its velocity is easily to be had. It has also other applications.

Nyrén, of Pulkova, has published an important paper on the position of the equinox for 1865.0, derived from observations of the sun made with the Pulkova transit instrument (Wagner) and vertical circle (Döllen and Gyldén). The deduced position of the equinox differs by $+0.064''$ from that assigned by Greenwich observations, by $+0.055''$ from Pulkova (1845), by $+0.011''$ from Paris, and $-0.002''$ from Washington.

Professor Wolf, of Zurich, who has collected all available data in regard to sun-spots for nearly twenty-five years, has now these data for more than 22,000 days between 1749 and 1876. Since 1848 these data may be said to be complete. The *mean* value of the solar-spot period he finds to be 11.111 years $\pm$ 0.307; but single periods *may* be two years longer or shorter than the mean. The maximum is nearer the preceding minimum than the following one. A longer period of about 178 years (not 55) is also indicated. It is to be noted that 16 sun-spot periods, 15 revolutions of *Jupiter*, 6 of *Saturn*, and 298 of *Venus* are nearly equal.

Sun-spots continue to be observed photographically at Greenwich, Paris, Moscow, Toulouse, Kasan, Vassar College, and are observed visually at Madrid, Oxford, Berlin, Zurich, Leipzig.

Protuberances are observed at Palermo, Rome, Greenwich, Moscow, O'Gyalla, etc.

The chief signal-officer of the army has proposed to the various observatories of this country, both public and private, to co-operate in physical observations of the sun. Every phenomenon of interest should be registered, whether relating to spots, faculæ, or protuberances, etc. Each observatory that is willing to take up any special field, or that already occupies such a field, is requested to give its results, or such part of them as it is willing to give, to the Signal Bureau for record in its *Monthly Weather Review*. Thus a prompt publication is secured. In response to this invitation, the United States Naval Observatory is furnishing a record of the number of spots daily observed on the sun's disk. This record is prepared by Mr. D. P. Todd. It is to be hoped that a regular series of photographic records of sun-spots can be made by some one or more observatories in the East, and by at least one on the Western coast. In order to render such observations of the sun complete, the establishment of these stations and one in Japan is required.

Captain J. Waterhouse, of India, publishes a very complete account (illustrated with photographs) of the preparations by himself and Tacchini to observe the solar eclipse of 1875, April 6, in the Nicobar Islands. No photographs of the spectrum of the corona were obtained, on account of cloudy weather, but the details of the methods adopted are of value.

Sir George Airy sends to *Nature* a list of thirty-seven ancient eclipses which have been computed by Hind, and of which the original manuscript calculations are preserved at the Royal Observatory. The earliest of these is B.C. 885, the latest A.D. 1652. There are twenty-one previous to the Christian era, and sixteen after it, and the whole is a most valuable contribution to chronology and the history of astronomy. Celoria, of Milan, has also published in No. XI. of the publications of that Observatory a discussion of the solar eclipses of 1239, June 3, and of 1241, October 6.

The important total solar eclipse of 1878 will probably be well observed in America. Estimates for $8000 have been submitted to Congress for American parties.

The reductions of the American Transit of *Venus* observations are in a forward state.

A discussion of the telescopic observations of the late transit of *Venus* made by the British expeditions has been laid before Parliament. In this preliminary result the internal contacts observed at five stations have been made use of, viz.: Honolulu, ingress accelerated; New Zealand, ingress retarded very slightly; Rodriguez and Kerguelen, ingress retarded; Egypt (Mokattam, Suez, and Thebes), egress retarded; Rodriguez, egress retarded very slightly; Kerguelen, egress accelerated. The value of the sun's parallax thus found is 8.760″, with a probable error of 0.013″, corresponding to a distance of 93,300,000 miles, with a probable error of 140,000 miles. According to Christie, of Greenwich: "Although there may be some small corrections to be applied to the individual results for errors in the provisional longitudes used, their amount can be but small, and it is hardly conceivable that the mean value can be sensibly affected. Nor is there any possibility of materially altering the result by another interpretation of the language of the observers concerned. We must, therefore, accept the fact that these observations of the transit of *Venus* give a value for the sun's parallax which is considerably less than most of those which have been recently put forward, though still decidedly larger than Encke's result. There remain, however, the observations made in India and Australia, which will reinforce the rather meagre results for egress, and also the measures of photographs which promise to give a very accurate value of the parallax."

Deichmüller, of Bonn, has published an investigation of the circumstances of the transit of *Venus* in 1882; it has been compared with a discussion lately published by Peter, of Leipzig.

Mr. David Gill, of England, has taken up his residence at Ascension Island, for the purpose of making heliometric observations of Mars to determine the solar parallax. The heliometer to be employed is the one used by Mr. Gill in the Transit of Venus Expedition of Lord Lindsay in 1874, in which *Juno* was observed and the parallax 8.82″ deduced. This expedition is of great importance, in many ways, as it is quite possible that from its results the best determination of solar parallax may be had, as the method employed admits of great refinement. The support given to the expedition is also noteworthy, as the Royal Astronomical So-

ciety guarantees the expenses, £500, and as many observatories will join in the fixing of the star-places, etc. It contrasts with the unfortunate expedition of Gilliss in 1849–52, who, on his return to the United States from Chili, found that his brilliant labors in the same field, although by a different and less independent method, had been practically in vain, through the feeble support given by Northern observers. Mr. Gill will also observe three of the asteroids for the determination of the solar parallax.

The photographs of the transit of *Venus* obtained by the United States parties have been examined, and all those which were capable of measurement have been read off. They are as follows:

Northern Stations.

Wladiwostok	13	plates.
Nagasaki	50	"
Peking	26	"
Total	89	"

Southern Stations.

Kerguelen Island	8	plates.
Hobart Town	38	"
Campbell Town	32	"
Queenstown	47	"
Chatham Island	7	"
Total	132	"

The grand total for both hemispheres is 221 plates. Owing to the great variability of the photographic diameters of the sun and *Venus*, it was found impossible to make use of any pictures which did not show a complete image of the sun. This excluded several hundred small photographs taken near the times of contact between the limbs of *Venus* and the sun.

The above-mentioned measurements of the photographs have been so far reduced that the position-angles of *Venus*, relatively to the centre of the sun's image, and the positions of the sun's image relatively to the centres of the plates, have been tabulated.

Their further reduction is under way, and it is expected that the reduction of all the observations of the transit itself will be brought to a close by the coming spring. It is also

hoped that the observations for longitudes of stations will be reduced before the end of the fiscal year, and with the present appropriation.

The question of the best means for determining the solar parallax will receive new light by the publication of the results of the heliometer measures of *Juno* by Lord Lindsay and Mr. Gill at Mauritius in 1874. The preliminary results obtained show a surprising accordance between the several nights' work, and indicate a parallax not far from 8.82″.

Another method promising good results is the observation of *Mars* and companion stars at the opposition of 1877; and to facilitate the application of this method, Professor Eastman, of Washington, has prepared a carefully selected list of stars for observation on the meridian with the planet during the period from July 18 to October 12, with suggestions as to the method of observation.

At the private observatory of Lewis M. Rutherford, Esq., New York, Mr. Chapman is making a series of photographs of *Mars* and comparison stars, which are afterwards to be measured. Two or more photographs are taken 3 h. *east* of the meridian, and the same number 3 h. *west*, so that from such a series the diurnal parallax may be had.

It is said in *Nature*, of January 18, that the measurements of the French photographs of the transit of *Venus* is not progressing favorably, unforeseen difficulties having arisen. Only forty-seven out of one thousand have been measured.

All the observations of the transit of *Venus* made by Russian expeditions will be collected and published in one volume, which is preparing at the Pulkova Observatory.

PLANETS, ASTEROIDS, AND SATELLITES.

Volumes X., XI., and XII. of the *Annales* of the Paris Observatory have arrived in the United States. They are mainly occupied with the development of Leverrier's theories of the motion of *Jupiter*, *Saturn*, *Uranus*, and *Neptune*. Vol. X. contains an important paper by Wolf and André on the "black drop," with experiments. The Observatory has also published a series of six ecliptic charts in continuation of Chacornac's.

Leverrier's researches on the planet *Vulcan* were concluded early in 1877. After an examination of all probable hypoth-

eses, the conclusion was that, to observe the planet *in transit*, astronomers must wait till 1881 or 1885, although there is a *possibility* of a transit in 1877. It has been suggested that the total solar eclipse of 1878 will be a favorable opportunity to search for it; and if an approximate position of it for that time is given, the planet must be sure of detection, if it really exist.

Lassell, of England, examined *Venus* on the 12th and 13th of July for the purpose of seeing the unilluminated portion of the disk, but he was not successful.

Ertborn, of Antwerp, publishes in the *Bulletin* of the Belgian Academy a series of observations on spots on *Venus*.

Trouvelot, of Cambridge, is still pursuing his observations of the planets. During the present year he has made 112 sketches of *Jupiter*, 80 sketches of *Mars*, and several of *Saturn*. The weather has been unfavorable for *Mars*, and a quiet atmosphere has not yet been obtained. A spot which appeared on *Jupiter* April 15 is still visible, and has been observed by Trouvelot twenty times. The adopted period of rotation does not agree with that indicated by the spot. If the adopted period be correct, the spot has a retrograde proper motion of great regularity, "almost too regular," as M. Trouvelot remarks.

Mr. Brett has published speculations on the "specular reflection" of *Venus*, the main idea of which is that *Venus* reflects the sunlight from a vitreous envelope, much as a thermometer-bulb would do. Mr. Brett suggests to observers of the next transit of *Venus* the propriety of looking in the globe of *Venus* for a reflected image of the earth, which will appear as a "minute nebulous speck of light." This "nebulous speck" would be less than one fiftieth of a second of arc in diameter. Considering the difficulty of seeing *Venus* herself when very close to the sun, the hope of carrying out the provisions of this plan is rather a forlorn one, particularly as the light of this "speck" is diminished by reflection, and is to be seen close to a bright background.

On December 7, 1876, Professor Hall, of the Naval Observatory at Washington, discovered on the disk of *Saturn* a brilliant oval white spot, which was observed to move across the disk for about an hour. It was central at 6 h. 18 m. Washington mean time. Information was sent to various observato-

ries in the United States, and observations were received from Edgecomb at Hartford, Mitchell at Vassar College, Boss at Albany, and Clark at Cambridge. It was first seen by Monckhoven, of Gand, December 6, at 22 h. 15 m. sidereal time, and was then about central. It should be noted that the rotation time of *Saturn's ball*, as given in many modern books (10 h. 29 m.), belongs to the *ring* (Laplace, "Mécanique Céleste"), while the true rotation time is near that given by Sir William Herschel (10 h. 16 m. 0.44 s.). Observations of this bright spot on *Saturn* were obtained through sixty-one revolutions of *Saturn's* ball. The resulting rotation time is 10 h. 14 m. 23.8 s.±2.30 s., which differs from Sir William Herschel's determination (10 h. 16 m. 0.4 s.) by less than 2 m.

Marth, of London, continues the publication of an extended ephemeris of the satellites of *Saturn*. These objects are observed by Hall, of Washington, at Greenwich, by Pratt at Brighton, and by Pritchett, of Glasgow, Missouri.

Professor Hall has given in the *Astronomische Nachrichten* elements and an ephemeris of *Hyperion*, the faint satellite of *Saturn*, derived from his own observations. Although these elements are regarded only as provisional, the inclination in particular requiring further observations to determine it, they are very close approximations, as is shown by the accordance of the ephemeris with the Washington observations of 1877.

With regard to Hall's elements of *Hyperion*, Hind remarks that they lead to the following numbers, assuming the solar parallax as 8.86″: mean distance, 914,000 miles; least distance, 800,000 miles; greatest distance, 1,028,000 miles.

In *Comptes Rendus* (March 26), Tisserand gives the results of his observations of the five interior satellites of *Saturn*. *Mimas* has been observed five times, *Enceladus* seven times, etc. Tisserand gives the apparent diameter of the ring, as deduced from observations of three of the satellites, as below: *Tethys*, 40.45″; *Dione*, 40.61″; *Rhea*, 40.47″; mean, 40.51″—which shows that the method of observation adopted (William Herschel's and Lassell's) is susceptible of great accuracy.

Professor Hall read to the Philosophical Society of Washington a paper on the shape of the shadow of the ball of *Saturn* on the ring, in which mention was made of the ab-

normal direction of the curvature of the bounding-line of the shadow, it being now *convex* towards the ball, instead of *concave.* The abnormal figure of this shadow has often been noticed, and is corroborated by many independent observers. In particular the drawing of the shadow by M. Trouvelot, October, 1874, is undoubtedly correct, as other drawings made at the same time by other observers give the same appearance.

Todd, of Washington, has prepared a continuation of Damoiseau's tables of the satellites of *Jupiter*, which extends to 1900. This has been printed by the American Ephemeris in a quarto of forty pages, and will be sent to any astronomer having a copy of Damoiseau. The errata in Damoiseau's tables found by Hind, Kendall, and Todd, respectively occupy nearly three quarto pages. The British Nautical Almanac for 1881 contains tables with a similar object by Professor J. C. Adams.

An outer satellite of *Mars* was observed by Professor Asaph Hall, U.S.N., at the United States Naval Observatory, on the night of the 11th of August, 1877. Cloudy weather prevented the certain recognition of its true character at that time. On August 16 it was again observed, and its motion was established by observation extending through an interval of two hours, during which the planet moved over thirty seconds of arc.

An inner satellite was first observed on the night of August 17, also by Professor Hall. Both were discovered with the 26-inch telescope made by Alvan Clark and Sons.

On Saturday, August 19, the discoveries were telegraphed to Alvan Clark and Sons, Cambridgeport, Massachusetts, in order that, if the weather should be cloudy at Washington, they might confirm the existence of the satellites with the 26-inch telescope of Mr. M'Cormick, which is in their hands.

These discoveries were confirmed by Professor Pickering and his assistants, at Cambridge, Massachusetts, with the 15-inch telescope, and by the Messrs. Clark, at Cambridgeport, with a 12-inch glass.

On August 19 the discoveries were communicated to the Smithsonian Institution, by which they were announced to the American and European observatories. The period of the *outer* satellite is about 30 h. 18 m.; of the *inner*, 7 h. 35 m.

The inner satellite is intrinsically the brighter, and the outer one has been seen with the 9.6-inch Munich equatorial at Washington. The most remarkable point of this important discovery is the short period of the inner satellite, which is only one third as long as that of *Mimas*, the innermost satellite of *Saturn*, hitherto the object having the shortest period in the solar system.

Apart from the physical interest of these brilliant discoveries, these satellites will furnish an accurate determination of the mass of *Mars*. From the observations of the first nine days this mass appears to be $\frac{1}{3090000}$. The discussion of all the observations will change this somewhat.

A curious fact about the relative visibility of these satellites in various European telescopes is noticed elsewhere. Photometric measures of the satellites of *Mars* have been made by Professor Pickering and Mr. S. C. Chandler.

The series of observations made by Professor Hall on the moons of *Mars* ended October 31, the planet having receded to a distance at which they become invisible, even with the 26-inch refractor. Not until 1879 will there be any opportunity to see them again, and that will not give nearly so good a view as the past season. Professor Hall has secured fifty-one observations of the outer (*Deimus*) and forty-six of the inner satellite (*Phobus*).

A passage in the 15th book of the "Iliad," where Ares is preparing to descend to the earth, has suggested these names for the two satellites of *Mars*, which names, it is understood, Professor Hall has approved:

> "῟Ως φάτο καὶ ῥ' ἵππους κέλετο Δεῖμόν τε Φόβον τε
> Ζευγνύμεν" . . . .

which Pope renders—

> "With that he gives command to Fear and Flight
> To join his rapid coursers for the fight."

Deimus and *Phobus* are the names adopted.

Todd, of Adelaide, Australia, has made an important series of observations of the phenomena of *Jupiter's* satellites. Besides the record of the times of the phenomena, notes on the physical appearances of *Jupiter* and the satellites are given. "On one or two occasions when a satellite has been on the point of occultation it has appeared as if seen *through* the edge of the planet, as if the

latter were surrounded by a transparent atmosphere laden with clouds."

Dr. Meyer, in the *V. J. S.* of the Philosophical Society of Zurich, has an interesting *résumé* of the history of the discovery of *Neptune*, which is one of the best of the shorter accounts of this discovery; and in No. 37 of the *Astronomische Mittheilungen* he gives a brief but excellent sketch of the history of double stars, together with a series of measures and an investigation of the orbit of Σ 634.

The *Astronomische Nachrichten* also contains an account by Galle of the discovery of *Neptune*.

Peters, of Clinton, notes a striking similarity between the orbits of *Gerda* (122) and *Urda* (167), their elements being alike except in one point. They move in one orbit about the sun, in the same periodic time, but are about 180° apart.

In the Smithsonian Report for 1876 Kirkwood has a statistical paper on the asteroids, in which the distribution of their perihelia, etc., is considered, and the analogies of the elements of their orbits are noted, and the same subject has been considered by Luther.

In a note by the veteran observer of asteroids, Luther, it appears that in the last twenty-nine years he has made no less than 819 observations of 98 asteroids!

Mr. Stockwell, of Cleveland, in studying the orbit of the asteroid *Gerda*, which has been observed in 1872, 1873, 1874, 1876, and 1877, finds that the *ensemble* of the observations leads to corrections to the elements which are quite inadmissible. The omission of the observations of 1873 leads to elements which almost perfectly represent the observations of 1872, 1876, 1877, but leave residuals of 27′ (α) and 9′ (δ) for 1873. Using the 1873 observations alone, elements are obtained which satisfy them within less than 1″ in both coordinates. The two sets of elements are closely alike in four elements, but the major axes make an angle of 5° or more. It is probable, according to Mr. Stockwell, that the planet of 1873 was not *Gerda*.

We have had to record the rediscovery of *Maia* (66), and by a similar process *Camilla* (107) has also been found. Schulhof prepared an ephemeris from January 8 to February 25 from the various systems of elements heretofore determined. That the uncertainty of this was enormous may

be seen from the fact the R. A. on January 8 might have been between 7 h. 35 m. and 10 h. 29 m. The space to be examined was divided between Paris, Marseilles, Berlin, and Pola. On the 2d of March, Palisa, of Pola, after having mapped 2800 stars, detected the missing asteroid.

ASTEROIDS DISCOVERED IN 1877.

Date.	No.	Name.	Mag. at Discovery.	Discovered by	No.	Observatory of
Jan. 10	170	Myrrha		Perrotin	4	Toulouse.
Jan. 13	171	Ophelia		Borelly	8	Marseilles.
Feb. 5	172	Baucis		Borelly	9	Marseilles.
Aug. 2	173		10	Borelly	10	Marseilles.
Sept. 3	174		11	Watson	20	Ann Arbor.
Oct. 1	175		11	Watson	21	Ann Arbor.
Oct. 14	176	Idunna	11	Peters	27	Clinton.
Nov. 5	177		10.4	Paul Henry		Paris.
Nov. 6	178		11.5	Palisa	11	Pola.
Nov. 11	179		11	Watson	22	Ann Arbor.
Dec. 29	180?	Eva?	11	Palisa	12	Pola.

Lumen, 141, was independently discovered by Watson and Borelly in August, and *Athor*, 161, in Oct., by Palisa. The column "No." gives the current number of each astronomer's discoveries.

THE MOON.

Professor Newcomb, of Washington, has published an investigation of corrections to Hansen's tables of the moon, with tables for their application, forming Part III. of papers printed by the United States Transit of Venus Commission. The object of the memoir is to aid in the reduction of the occultations observed by the various parties for longitude.

In this paper is announced the discovery of an inequality in the longitude of the moon, which has a period of 27.4 days. It can be put in the form

$$\delta v = +1.5'' \sin. [g + 21.6° (Y - 1865.1)],$$

g being the mean anomaly.

This term was deduced empirically from a discussion of corresponding Washington and Greenwich observations. More recently Neison, of England, has given an account of some lunar perturbations produced by *Jupiter*, and has shown that these gave rise to a new periodical term in the moon's longitude, which could be expressed by

$$\delta v = +1.163'' \sin. [g + 20.85° (Y - 1864.4)].$$

From this it follows that we have to do with a real inequality theoretically deduced by Neison. The agreement between the theoretical and Newcomb's empirical term is a satisfactory one. The two independent results confirm each other and dispose of the doubts expressed as to the reality of this term.

The numerical lunar theory of Sir G. B. Airy is in a forward state, and one section of it is to be printed as an Appendix to the forthcoming volume of Greenwich observations.

Dr. George W. Hill, of the *American Ephemeris*, has recently printed (privately) an exhaustive treatise on that part of the motion of the lunar perigee which is a function of the mean motions of the sun and moon. From this work we learn that its author is also engaged in other researches in the lunar theory, which are shortly to be published. This work of Dr. Hill has met with a most cordial appreciation abroad from Professors Cayley and Adams. The latter confirms its principal conclusions from unpublished researches of his own.

In a recently published pamphlet on astronomy in Rome during the pontificate of Pius IX., Secchi gives an account of his unpublished observations on the lunar surface.

Professor Alexander, of Princeton, has brought forward a variety of evidence tending to indicate some envelope, like an atmosphere, for the moon. This evidence was principally drawn from observations during eclipses.

The work of Professor Newcomb on the Lunar Theory, after suffering an interruption of some years, was recommenced in 1876. That part of it which consists of a new reduction and examination of all recorded eclipses and occultations of value before 1750 is substantially complete, most of it being in the hands of the printer. The ancient observations which have been considered most reliable indicate a correction of more than half an hour to the times of ancient eclipses as hitherto calculated from the tables. This correction so changes the computed paths of the moon's shadow during total eclipses that the chronological questions involved in them will no doubt have to be re-examined. The most remarkable result of the research is that the motion of the moon during the past 250 years may be very

closely represented by the alteration of a single term in Hansen's tables. The question whether this alteration is admissible in the theory cannot yet be decided.

COMETS.

The recent dearth of comets has been supplied in 1877 by the discovery of five. Comet *a* was discovered by Borelly, of Marseilles, on February 8, and was visible as a telescopic object till March 18 in Europe, but was observed by the 26-inch telescope at Washington so late as March 30. It had the usual comet spectrum. Comet *b* was discovered by Winnecke, of Strasburg, on April 5. Young, of Dartmouth, and Wolf, of Paris, have investigated its spectrum, which is of the usual type. Comet *c* was discovered by Swift, of Rochester, on April 10, and independently by Block, of Odessa, on the same date, and by Borelly on the 14th. Comet *b* remained a tolerably bright object until some time in July. Comet *c* was always faint. There is a strong resemblance between the elements of comet *c* and those of the comet of 1762, but the researches of Holetschek indicate that these are different bodies.

D'Arrest's comet was found by Tempel, of Florence, in the place indicated by Le Veau's ephemeris.

Comet *e* was discovered by Coggia, September 13, and *f* by Tempel, October 2.

In regard to comet *b*, 1877 (Winnecke's), the discoverer has remarked that a similarity exists between its elements and those of comets II. 1827 and II. 1852. The intervals 1827–52 and 1852–77 being equal (twenty-five years) lends additional strength to the supposition of identity. This question is remarked upon by Hind in *Nature* (April 19), who says: "The case is a very curious one, and possibly unique of its kind: similarity of elements at three epochs separated by very nearly equal intervals; and on the assumption of a corresponding period of revolution, a very near apparent approach to the planet (*Jupiter*) which so greatly disturbs the cometary orbits; yet action to account for outstanding differences of elements could not have taken place on either occasion of the comet's passage through that part of the orbit where great perturbation would be looked for."

The *Annals* of the Moscow Observatory (Vol. III., Part I.) contains an important paper by Bredichin on the anomalous forms in the development of the tails of comets, with especial reference to comet II. 1862, and a reduction by Gromadski of meridian observations of fundamental stars by Bredichin and Khandricoff. The results of the first of these papers have been published in the *Astronomische Nachrichten.*

Dunér publishes in the Proceedings of the Stockholm Academy, 1876, No. 1, a paper on Coggia's comet of 1874, accompanied by nine drawings.

SPECTROSCOPIC OBSERVATIONS.

No publication in regard to photographic spectra of stars has been made by either Dr. Huggins or Dr. Draper since the first announcement of their preliminary results. It is understood that the observation of the spectra of fixed stars will be a principal work of the new observatory of Princeton College.

Dr. Konkoly, of the O'Gyalla Observatory, in Hungary, has recently communicated the result of his observations on the spectra of 160 fixed stars to the Hungarian Academy of Sciences. The bright bands in the spectrum of *Beta Lyræ*, found by Vogel in 1871, and previously by Secchi, are now wanting.

Secchi publishes a list of 444 colored stars from Schjellerup's list and his own observations, with notes on their spectra, etc. It is noteworthy (and little known) that Sir William Herschel recognized the essential differences of the first three types of Secchi so early as 1798. (See *Phil. Trans.*, 1814, page 264).

The change of spectrum of *Nova Cygni* is noticed in another place.

ZODIACAL LIGHT.

From information received from Mr. H. C. Lewis, of Germantown, we learn that he continues to see the zodiacal light from horizon to horizon, and also that the veritable *Gegenschein*, as an oval spot of light in the zodiacal light, appears distinctly, and from month to month shifts its place in the stars so as to keep about opposite the sun.

In the *Comptes Rendus* for July 2, Hugo has a note on a luminous column vertically extended above the moon, and some four degrees in length; and Trouvelot has recently

published in the *Proceedings* of the American Academy a note on a similar phenomenon, under the caption "The Moon's Zodiacal Light." In the Paris *Memoirs*, 1771, p. 434, Messier describes a similar phenomenon, which has never yet been explained, and gives a wood-cut of its appearance.

TIME.

One of the few ways in which astronomy can make itself practically valuable to the community at large is in the dissemination of standard time to navigators and to men of business. The following notes refer to what has been done in this direction during 1877.

The recent invention of Barraud and Lund, of London, for controlling a clock by automatic or other signals is described in an advertisement in the *Telegraphic Journal* for May, 1877. It has the capital advantage over the Bain system that the clock may run *either* fast or slow without affecting the control. It suffices to control a clock whose rate is ± 2 minutes daily. It appears to be a suitable device for the regulation of the clocks of manufactories, railways, churches, etc., where a control to the nearest minute is all that is required, and where economy is necessary. In this connection it may be noted that the Paris Observatory now controls the clocks of the Conservatoire, St. Sulpice, and the Luxembourg, and the system is to be extended to the clocks of the various cab-stands, which will be a very practical and valuable step.

The public clocks of Vienna are controlled by a pneumatic-motor clock which is said to have been very satisfactory.

The Trinity House of England is adopting gun-cotton as a means for fog-signals, and it may prove a valuable substitute for the time-guns now established in the various ports of the world in cases where the sound only is available for signals. Where the flash can be observed a gun is preferable, or an electric light, as used at Melbourne.

Redier describes in the *Comptes Rendus* a simple device for correcting the going of clocks for changes in rate due to changes of atmospheric pressure, by means of a small aneroid barometer fastened to the pendulum bob.

The Naval Observatory of Washington has been for some

time dropping a time-ball erected by the Western Union Telegraph Company on their main building in New York City. The ball is dropped at New York noon, for the benefit of navigators and others. This ball has been in operation for four months without a single failure. It is always within 0.5^s of the truth, and every day its error is published in the New York papers, so that it is practically a perfect signal.

A similar one is to be erected at Baltimore at the expense of the Baltimore Board of Trade.

The Observatory of Harvard College offers to supply standard time to railways and others in New England in extension of its present system, which is already widely useful.

The Navy Department has printed an important paper on the rates of chronometers as affected by temperature, by Lieutenant-Commander C. H. Davis, U.S.N., and the same subject is elaborately treated by MM. de Magnac and Villarceau in "La Nouvelle Navigation."

INSTRUMENTS AND OBSERVATORIES.

Astronomical Instruments.

Alvan Clark and Sons, of Cambridgeport, have just completed an 11-inch photographic refractor for the Lisbon Observatory. It can also be used for visual purposes. The general design of its mounting is very stable and elegant. They have also finished the objective of a new 9½-inch equatorial for Princeton College. It is constructed on Gauss's curves, and is said to be very fine and to have decidedly less outstanding color than the ordinary forms of this aperture. The crown-glass is capable of being rotated in the cell of the flint, and is thus separated from it. In this way it is intended to adapt this objective to photographic work. No crown-glass has yet been ordered for the 27-inch flint-glass belonging to Yale College, and the M'Cormick 26-inch glass is still in the workshop, although it is fully completed.

Mr. Howard Grubb, of Dublin, publishes an important paper on the great telescopes of the future, in which he discusses, first, the advantages of each class of instrument, and, second, the effect upon these advantages of increasing

the size. He gives the considerations which indicate in what respect important advances in the art of instrument-making are to be looked for. First, Mr. Grubb says that beyond an aperture of 35.435 inches reflectors will have the advantage over refractors. Refractors have the advantage in their "greater permanence of collimation, and consequent suitability for ordinary observatory work, and for measuring purposes," as also in permanence of the optical parts, in the fact that they have no central mirror to disturb the course of the rays, and the comparatively slight effect of air-currents upon them, since the tubes can be closed at both ends. The advantages of reflectors are absence of a secondary spectrum, better applicability for work in celestial photography, photometry, spectroscopy, etc.; the possibility of supporting them with perfect freedom from flexure irrespective of size (perhaps this conclusion of Mr. Grubb will not be generally accepted), and their general convenience for observing purposes. Mr. Grubb looks with most hope to large metal specula for the best results.

The question of the relative goodness of reflectors and refractors has some light thrown upon it by recent observations of the satellites of *Mars*. These were both easily seen and *measured* in a refractor of 12 inches aperture. The outer satellite has been certainly seen with a refractor of 7 inches. With an 18-inch silvered-glass reflector, Key, of Hereford, was barely able to see the outer satellite when its exact position was known. At Marseilles the outer satellite has been observed with a refractor, but neither of the two has been seen with the reflector of 31 inches aperture, "on account of diffused light in the field." The silvering of this mirror has, however, deteriorated through age. With the 6-foot reflector of Lord Rosse the outer satellite alone was seen up to September 20, and "not well enough to measure it." At Melbourne neither satellite was seen with Mr. Grubb's 4-foot reflector, and we have no account of observations with Mr. Lassell's 2-foot reflector. As far as has been reported, not a single reflector has even *seen* the inner satellite.

At the same time Grubb also publishes his new illustrated catalogue of instruments, domes, etc., which is really an important addition to the literature of the subject. The cata-

logues of two American makers, Buff and Berger, of Boston, and Fauth and Co., of Washington, are noteworthy in this connection. The latter firm has lately proposed to make a transit-circle for Princeton College, which, when completed, will be the first meridian instrument of large size made in the United States. A transit instrument for the same college has been completed by Kahler of Washington.

The 18-inch refractor for Strasburg has had several objectives made for it by Merz, among which a choice must yet be made, and until then work on the mounting is stopped.

Grubb, of Dublin, has just completed two 8½-inch equatorials for Berlin and Dresden, in which he has incorporated his latest improvements with regard to illumination of field, wires, etc. *One* reading microscope suffices to read both declination and right-ascension circles.

The Naval Observatory of Washington has recently published a description of its principal instruments, with plates. It is Appendix I. to the Observations for 1874.

Titano-silicic glass prisms have been examined by Professor Stokes and Dr. Hopkinson, and the hopes that had been entertained of the utility of this glass in the correction of the secondary spectrum were not fulfilled. The phosphatic glass of Harcourt, while a success in this respect, is too soft for use in optical glass, and the new glass, in which a portion of the phosphorus was replaced by titanium, would have been suitable in this respect. The question is, then, as far from a practical solution as ever.

Experiments on the electro-static capacity of glass did not bear out Maxwell's conclusion as to the relation between the refractive index for long waves, the electro-static capacity, and the magnetic permeability.

The paper on the refractive indices of glass refers mostly to glasses which are articles of commerce, and hence is of immediate value. Specimens of hard crown, soft crown, titano-silicic crown, extra light flint, light flint and dense flint, extra dense flint, and double extra dense flint were examined, and an expression for the irrationality of dispersion of each of these glasses compared with a standard is obtained and tabulated. This table shows how little there is to choose between the glasses ordinarily used.

New Observatories.

Dr. Lohse contributes to the *Astronomical Register* for August an account of the Astrophysikalischen Institut, now building at Potsdam. It is on an elevated site, and the grounds contain 179,000 square meters. There are at present finished four dwelling-houses (three for observers and assistants) and the machinery-house. The observatory proper is in progress, and will be completed during 1877. One part of the scientific establishment is already completed, viz., a well of forty-six meters deep, with horizontal shafts connected with it. This is to serve for observations where a constant temperature is required, for observations on the temperatures of the soil, etc. The observatory will have three domes—a central (to contain a 12-inch equatorial by Schröder), a western (to contain an 8-inch by Grubb), and an eastern (to contain a 5-inch). A photoheliograph will be erected north of the central tower, and the physical, chemical, and photographic laboratories will be suitably placed in the main building. The work undertaken will be spectroscopic observations of the sun and stars, observations of the nebulæ and double stars, on the physical nature of the planets, etc., photographic researches of all kinds and photographic registration of sun-spots. The observatory is managed by a "Direction" of three members — Auwers, Förster, and Kirchhoff. At present there are three astronomers—Vogel, Spörer, and Lohse.

The Wilna Observatory was destroyed by fire on December 28, 1876. In spite of strenuous efforts, only some of the books and smaller instruments were saved. The refractor and the photoheliograph were totally destroyed. This is much to be regretted, as we owe to Wilna a large number of excellent photographs of the sun, a regular series of which was kept up. It is to be hoped that the negatives of these photographs have been preserved.

Ex-Governor C. C. Washburn intends, during the next year, to erect and equip an astronomical observatory for the University of Wisconsin. This gift will be made available by an annual appropriation for its support from the state. The firm of Clark and Sons are now making a 16-inch equatorial for this observatory.

The Troy Polytechnic School is fitting up an observatory in connection with its courses of study.

A new observatory has been founded at Lyons, France, of which André has been named director. Its meridian-circle was presented by M. R. Bischoffsheim, of Paris.

The observatory at Kiel is now in its new building, and has lately received a new refractor, by Steinheil, of eight inches aperture. Its meridian circle is engaged in observing a zone of stars of less than 10° N. P. D.

A sum of $12,000 has been devoted by Oxford University to the building of additions to the observatory.

Professor Young has accepted the chair of astronomy at Princeton. He will have a large telescope at his disposal.

The third volume of André and Rayet's *Astronomie Pratique* (History of Observatories) is concerned with the observatories of the United States, and will be found a useful book of reference. It is compiled from the notes of M. Angot, one of the editors. It supplements the older works of Loomis and Mailly.

Publications and Reports of Observatories.

The report of the Secretary of the Navy for 1877 contains that of the Superintendent of the Naval Observatory, which gives an account of the work of the past year. The 26-inch equatorial continues to be used in the observations of the faint satellites. The transit circle, besides its regular work of observations of the sun, moon, and major planets, has made a very large number of observations of asteroids, and is also engaged in the formation of a catalogue of the B. A. C. stars between 120° 0′ and 131° 10′ of N. P. D. The old meridian instruments are in use for completing Yarnall's catalogue, of which a second edition is in preparation. The investigation of the moon's motion is continued. The transit of Venus reductions are in progress. The photographs of the transit are now measured. The division errors of the ruled-glass scale micrometer have been carefully determined.

The bill introduced in the United States Senate, to provide for the removal of the Naval Observatory, directs the Secretary of the Navy to appoint a commission of three members to select a new site within the District of Columbia, which shall possess the advantages of healthfulness,

clearness of atmosphere, and convenience of access from the City of Washington, and upon receipt of the report of this commission to purchase said site, accept such plans as he may deem suitable to proceed with the erection of the observatory and its appropriate buildings. The bill for this purpose appropriates $300,000, or as much thereof as may be necessary, provided the aggregate cost shall not exceed that sum, and that no expenditures shall be made until approved. It also directs the Joint Committee on Public Buildings and Grounds to take such measures as may be fit and expedient to sell the present observatory reservation, the sale to take effect after the removal of the observatory, and the proceeds to be covered into the United States Treasury. The bill furthermore provides for the transportation and use, in the new building, of any materials belonging to the present observatory.

The transit of Venus papers of the English commission are now in the hands of the printer, and the first part has been issued.

The eleventh annual report of the Board of Visitors of the Melbourne Observatory describes the work of the past year (to 1876, June), which has been the usual meridian observations, drawings of over seventy southern nebulæ, daily photographs of the sun, etc., etc., and describes a plan for enlarged meteorological activity, which will probably be adopted.

The report of the Oxford University Observatory for the year 1876–77 records the taking of 426 lunar photographs (making 652 taken to date), which are to be measured micrometrically for the determination of the *libration;* 117 double stars have been measured during the year (259 measures), and six satellites of *Saturn* observed; the chromosphere has been delineated on twenty-two days. The director describes a new micrometer, which appears to be similar to Alvan Clark's *double eye-piece* micrometer, described some twenty years since. One of these is now at the Naval Observatory, Washington.

The volume of the Cape Observations for 1874 is the thirteenth publication circulated by Mr. Stone, the director, since his accession in 1871. It contains the mean positions of 1246 stars, including all of Lacaille's stars in the *Cœlum*

Australe Stelliferum which now fall between 155° and 165° N. P. D., and some additional ones in the same zone. Lacaille's stars between 145° and 155° N. P. D. were similarly observed in 1875, and those between 135° and 145° in 1876. We shall soon, therefore, have accurate places of all Lacaille's stars, especially as Dr. C. Powalky, of Washington, has reduced all of Lacaille's observations (about 400 in number) taken with the altitude instruments both at the Cape of Good Hope and at Paris. By introducing new values of the latitude, refraction, and corrections for the division errors of the instruments, he has been able to bring excellent agreement between the Paris and Cape observations with both sextant and sector. The results appear to be comparable in precision with Bradley's observations. The epoch chosen is 1750.0.

"The Results of Observations of Shooting-Stars, from 1833 to 1875," by the late Dr. Heis, of Münster, has just been published. It comprises Dr. Heis's own observations for forty-three years at the observatory of which he was director. According to *Nature*, it gives the times of occurrence and the points of first and last appearance of 13,000 meteors, followed by a partial discussion of the results and by a catalogue of radiant points.

ASTRONOMICAL BIBLIOGRAPHY.

The St. Petersburg Academy has published a "Tableau général méthodique et alphabétique des Matières contenues dans les Publications de l'Académie Impériale des Sciences, depuis sa Fondation." The first part, "Publications en Langues étrangères," 489 pp., 8vo, was printed in 1872, and has just reached England. It will be of immense service as a key to these important Transactions.

The continuation of the Royal Society's Catalogue of Scientific Papers (1864–73) is nearly ready for distribution. It contains over 95,000 titles, and will be printed in two volumes, uniform with the former volumes. Vol. VII. contains the initials A–H, Vol. VIII. H–Z.

The Royal Academy of Sciences of Belgium has recently published an important bibliographical work, which gives a complete list of the members, etc., of the Academy, and a list of the works of each, which is *complete* so far as its own

publications are concerned, and very full in the publications of other bodies. It is a useful supplement to the indispensable Royal Society catalogue of scientific papers.

Mr. Knobel, of England, has published in the *Monthly Notices*, Royal Astronomical Society, a very complete and accurate index catalogue to scientific literature on the subjects of Double Stars, Variable and Red Stars, Nebulæ, etc., Proper Motions and Parallax, and Stellar Spectra. Since this has appeared, a very complete bibliography by Mr. Knobel has been printed in the *Memoirs* of the same society under the title "Chronology of Star Catalogues."

The Smithsonian Institution has published a complete bibliography of works on Nebulæ and Clusters, by Professor Holden, of 110 pp., 8vo.

Professor Merriman, of Yale College, has published a valuable bibliography of works on the Method of Least Squares.

It is proposed to found an American journal of pure and applied mathematics at Baltimore, under the editorship of Professor Sylvester, aided by the professors of the Johns Hopkins University and others.

We note the establishment of a new astronomical periodical (monthly), under the editorship of Mr. Christie, first assistant at the Royal Observatory, Greenwich. He is to be assisted by several eminent astronomers. The first number appeared on April 20, 1877, under the name, *The Observatory: a Monthly Review of Astronomy*, and contains articles by Huggins, Gill, Darwin (G. H.), Birmingham, Tupman, Brett, and Marth.

The Science Observer, published monthly since July, 1877, as the organ of the Boston Amateur Scientific Society, contains notes on variable and double stars, etc.

The *Popular Science Monthly* for February, 1877, publishes a list of the principal telescopes of the world, which may be of use for reference.

REPORTS OF AMERICAN OBSERVATORIES.

For the purpose of rendering the summary of the progress and condition of astronomical science in 1877 fuller and more satisfactory, a circular was sent to the directors of the various observatories of the United States, asking for information on the following points:

First, the *personnel* of the observatory;

Second, its principal instruments;

Third, the subjects of observation to which attention has been devoted during the past year;

Fourth, those which will be taken up during the coming year; and

Fifth, the principal publications of the year.

To secure a fuller response to these inquiries it was suggested that a systematic presentation of the information in question, as derived from all the principal observatories, would serve the purpose of a permanent record in the absence of any journal in the United States specially devoted to such subjects. It was intended that one such circular should reach every observatory, public or private, in the United States. If any have been omitted, it has been by inadvertence, and notice of such omissions is desired by the editor.*

The various replies to this circular follow in the alphabetical order of cities, and are given *unchanged*, except that occasionally material elsewhere accessible has been omitted to gain space.

Dudley Observatory, Albany, N. Y.

Professor Lewis Boss, Director.

For some time previous to July, 1876, the astronomical office of the observatory had been vacant. At that date astronomical work was resumed, with a limited personal staff.

During the past year this has consisted of the director, Lewis Boss, and assistant, O. H. Landreth, with a janitor to care for the buildings and grounds.

The instrumental equipment of the observatory has received no material alteration for many years. The principal features of these instruments are described with more or less detail in Volume I. of the "Annals of Dudley Observatory." A mere enumeration is all that need be given here.

The principal instruments are:

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* This circular was sent to the observatories at Chicago, Albany, Hastings, Bethlehem, Amherst, Hartford, Cordoba, Pittsburgh, West Point, Vassar College, Clinton, Cambridge, New York, Cincinnati, Rochester, Williamstown, Middletown, Gettysburg, Hanover, Ann Arbor, Princeton, Quebec, etc.

1st. The *Equatorial Refractor*, of 13 inches clear aperture and 15 feet 2 inches focal length, made by Henry Fitz, of New York.

2d. The *Olcott Meridian Circle*, of 8 inches aperture and 9 feet 8 inches focal length, with circles of 36 inches diameter, graduated to 2′, made by Pistor and Martins, of Berlin. This instrument is supplied with collimators, reversing carriage, and other apparatus essential to its use.

3d. The *Transit Instrument*, of 6.4 inches clear aperture and 8 feet focal length, made by Pistor and Martins, of Berlin.

4th. The 4-inch *Comet-seeker*, by Alvan Clark and Sons, of Cambridgeport, Mass.

5th. *Two Standard Sidereal Clocks*, one clock regulated to mean solar time, and several *Counting Clocks.*

6th. A *Printing Chronograph*, by Professor G. W. Hough, and a *Disk Chronograph*, from designs by Professor Mitchell. These chronographs are entirely out of repair.

7th. A *Printing Barometer*, *Thermometer*, and *Anemoscope.*

8th. Miscellaneous apparatus of minor importance.

The observatory is supplied with an astronomical library of about 1000 bound volumes, besides numerous pamphlets.

During the term of office of the present director the buildings have been thoroughly repaired and the grounds improved.

Observations have been made, principally with the Equatorial Refractor and the Olcott Transit Circle.

The principal observations with the former instrument have been:

1st. Physical observations of *Mars* at opposition, with numerous measurements of the inclination of its polar axis.

2d. Observations of *Iris* at opposition for solar parallax.

3d. Observations of the position of small planets.

4th. Phenomena of *Jupiter's* satellites.

The Olcott Meridian Circle has been devoted—

1st. To observations of *Mars* during opposition, on the plan proposed by Professor Eastman, of the Naval Observatory.

2d. The positions of many small stars have been observed, both in right ascension and declination. Particular attention has been directed to stars of the sixth magnitude, or brighter, which at present lack satisfactory modern determinations.

3d. Observations of *Ariadne*, *Iris*, and *Melpomene.*

4th. Standard time has been furnished to the city of Albany, and to all railroads and telegraph lines radiating from this point.

5th. Many observations have been made for latitude, flexure, values of telescope micrometers and other instrumental constants.

During the year 1878 it is proposed to continue the observation of selected stars and asteroids. Plans for observations on a more extended scale are under consideration, but not fully matured. It

is not improbable, however, that a series of observations of the satellites of *Jupiter*, throughout its opposition, will be taken with the Equatorial.

An extended discussion of the declinations of 500 principal and miscellaneous stars, with reductions of nearly all published series of declinations to a homogeneous system, is in press. The results have already been incorporated in the *American Ephemeris* and *Nautical Almanac*.

Allegheny Observatory, Allegheny, Pa.

Professor S. P. LANGLEY, Director.

Replies to inquiries for information in circular of Professor S. F. Baird (without date):

1st. *Personnel* of the observatory: S. P. Langley, Director; R. F. Hall, Assistant to Director.

2d. Principal instruments: *Equatorial*, 13-inch objective, finished by CLARK, 15 feet 3 inches focus, 20-inch hour and declination circles. This instrument has a considerable number of attachments (besides the *Filar-position Micrometer*) fitting it for physical research. Such are a *Prism Spectroscope*, of HUGGINS's pattern, and a more powerful one using gratings; a *Polarizing Solar Eye-piece*, apparatus for projection, etc. An additional lens, 4-inch aperture, of about 150-feet focus (by CLARK), is mounted so that when used in conjunction with the 13-inch objective the so-called actinic rays from the central parts of the latter may be focussed together for photographic purposes.

An accessory part of the Equatorial, peculiar it is believed to this instrument, has been lately added, consisting of a 12-inch *Silvered Plane*, by CLARK, mounted at the southern extremity of the polar axis; so that a fixed solar beam may be sent down the prolongation of this axis by using the ordinary clock-work of the telescope, which, thus considered, becomes a great "Fahrenheit" Heliostat; change wheels in the driving-clock convert it at pleasure into an "August's" Heliostat, maintaining a fixed horizontal beam. In either position, heavy apparatus which could not be carried by the Equatorial can be mounted on a firm support and still used in connection with the telescope.

The other instruments are a *Transit* of the English pattern, 4 inches in aperture; a *Chronograph;* a *Sidereal Clock*, by FRODSHAM; a *Mean-time Clock*, by HOWARD; an *Accessory Clock*, by HOWARD; one *Break-circuit* and an ordinary *Chronometer*, both by FRODSHAM. Besides these, there are a number of minor instruments chiefly adapted to solar physical research.

3d. The principal subjects of observation of the past year have

been connected with solar physics, though studies for the preparation of an apparatus for eliminating personal equation in transit observations have occupied some time.

In solar physics, work is being done here now on the comparison of the heat of the sun with terrestrial sources, on the distribution of radiant energy in the spectrum, and on the change of wave-lengths of light from the different parts of the sun caused by rotation—the latter in connection with an appropriation from the Bache Fund—all in active progress. Besides these, other investigations in the same field are in progress.

The routine work for time-determinations has also always been carried on. Besides its work of research, this observatory has been, since 1870, the supplier of time to a large number of railroads, of which it is the official standard, and since to cities. The automatic signals from its mean-time clock have thus been transmitted from Pittsburgh to New York for the past seven years, and during the latter part of that time as far west as Chicago, and over about 6000 miles of main and branch railway lines daily, as well as to the city of Pittsburgh, etc.; and observations and computations for the control of these are made daily.

4th. The work of the coming year, it is anticipated, will be in solar physics very largely, and will, it is hoped, be made to include, for the first time, systematic solar photography. Pending the introduction of this, the usual daily studies of the solar surface will be continued, accompanied (as at present) with a daily drawing on a scale of 8 inches to the solar diameter, made by projection, and an enlarged drawing of any part of interest, made with the micrometer and polarizing eye-piece. A daily spectroscopic review of the solar limb will be made also, and most of the subjects already mentioned will be continued.

5th. The incompletion of work now in hand, and the desire to make a thorough presentation of it, have limited the publications of the past year. Three communications to scientific journals, describing results recently obtained here, have been made by the director in the *Comptes Rendus des Séances de l'Académie des Sciences* for May, 1877, and in *The American Journal of Science and Arts* for July and August, 1877.

Harvard College Observatory, Cambridge, Mass.

Professor E. C. Pickering, Director.

First. The observers and computers at present constantly employed at the observatory building are:

Edward C. Pickering, S.B., Phillips Professor of Astronomy and Director of the Observatory.

William A. Rogers, A.M., Assistant Professor of Astronomy.

Arthur Searle, A.M., Assistant.

Leonard Waldo, A.M., Assistant, in charge of the time-service.

Winslow Upton, A.M.; employed in work undertaken in aid of the Coast Survey, and in Equatorial observations.

Miss R. G. Saunders; employed in reductions of the observations made with the Meridian Circle.

Mr. Joseph F. McCormack; employed in assisting in the observations made with the Meridian Circle, and in reducing them.

Mr. C. H. Metcalf; employed in reductions of photometric work.

There are other persons not immediately connected with the observatory who are customarily employed in performing computations for it.

Second. The principal instruments of the observatory are:

The *East Equatorial*, a refractor of 15 inches aperture and 22½ feet focal length, made by MERZ, of Munich, and mounted in 1847.

The *West Equatorial*, a refractor of 5½ inches aperture and 7½ feet focal length, made by ALVAN CLARK AND SONS, and mounted in 1869.

The *East Transit Circle*, made by TROUGHTON AND SIMMS, and mounted in 1848. Aperture of telescope, 4½ inches; focal length, 5 feet.

The *Meridian Circle.*—The object-glasses of the instrument and of its collimators were made by ALVAN CLARK AND SONS; the metal work mainly by TROUGHTON AND SIMMS. The instrument was largely designed by the late director of the observatory, Professor Joseph Winlock, and has done great credit to his ingenuity. The aperture of the principal telescope is 8½ inches, and its focal length 9 feet 4.4 inches. The aperture of each collimator is 8 inches, and its focal length the same as that of the chief telescope. The instrument was mounted in 1870.

The *Portable Transit Instrument*, made by HERBST, of Pulkova, and mounted in 1870. Aperture of telescope, 2¾ inches; focal length, 33 inches.

Third. The subjects of observation to which attention has been devoted during the past year may be classified with regard to the instruments employed in investigating them.

The work done with the Equatorials has been principally photometric. The objects observed have been the satellites of the superior planets (including those of *Mars*), some of the asteroids, and some of the fixed stars. *Mars* and *Saturn*, and also *Jupiter* and *Venus*, have been compared with each other.

Micrometric measures have been made, chiefly of *Mars* and of its satellites.

The Meridian Circle has been employed, first, in observing the zone 50° to 55° north declination, undertaken by this observatory as its contribution to the work of determining the places of the stars

of the ninth magnitude, or brighter, belonging to the northern hemisphere; secondly, in observing the stars contained in a list drawn up to facilitate astronomical work of various kinds; thirdly, in observing *Mars* during the period of its opposition, with suitable comparison stars, and also some comparison stars for use by Mr. D. Gill in his observations of asteroids at Ascension Island.

Meteorological observations have been regularly made.

Special observations for clock-error are regularly made, to maintain the accuracy of the clock-signals transmitted to various points in this part of the country, for the purpose of supplying the community with a trustworthy standard of time.

Fourth. The work of the coming year will be a continuation of that just described, with the exception of the observations connected with the recent opposition of *Mars.* The stars of a list drawn up by the Coast Survey will also be observed at the request of that institution.

Fifth. The eighth volume of the *Annals* of the observatory was published in November, 1876; the tenth volume in the spring of 1877.

L. Trouvelot's Physical Observatory, Cambridge, Mass.

Observer, L. Trouvelot, occasionally assisted by Geo. H. Trouvelot.

Principal Instruments.—1st. *Equatorial Refractor*, by Merz, 6⅓ inches aperture, 8⅓ feet focal length.

2d. Rutherfurd's *Diffraction-plate Spectroscope*, by Alvan Clark and Sons.

3d. *Apparatus for Photographing the Sun-spots.*

The observatory was built early in 1875, and observations begun March 15 of the same year.

During the years 1875, 1876, and 1877, close attention was given to the Sun, Moon, Planets, Clusters, Nebulæ, Double Stars, Meteors, Zodiacal Light, and the Auroral phenomena. From March 15, 1875, to November 30, 1877, the following observations were made:

The Sun	was observed	955	times,	and	48	drawings	made.		Diagrams	made.
The Moon	" "	154	"	"	26	"	"			
Mercury	" "	12	"							
Venus	" "	144	"	"	16	"	"			
Mars	" "	189	"	"	148	"	"			
Jupiter	" "	290	"	"	269	"	"			
Jupiter's Satellites		35	"	"		"	"	35	"	"
Saturn	was observed	136	"	"	12	"	"	67	"	"
Uranus	" "	1	"							
Comets	" "	7	"	"	5	"	"			
Nebulæ	" "	170	"	"	46	"	"			
Clusters	" "	12	"	"	1	"	"			
Double Stars	"	54	"	"		"	"	19		

Total of observations, 2159; drawings, 571; of diagrams, 121

The Zodiacal Light and the Milky-way have both been particularly studied on every favorable occasion, and elaborate drawings representing them in their most characteristic appearances have been produced.

Besides, a series of thirty-four astronomical drawings in pastel was prepared from the above observations and drawings, and exhibited at Philadelphia at the International Exhibition.

Comparatively few of the results of these observations have yet been published. In 1875 two papers were communicated to the American Academy of Arts and Sciences: 1st. "On Some Physical Observations on the Planet Saturn;" 2d. "On Veiled Sólar Spots." In 1877 three papers were presented to the Academy: 1st. "On the Moon's Zodiacal Light;" 2d. "Vibrations Observed in the Tail of Coggia's Comet;" 3d. "Sudden Extinction of the Light of a Solar Protuberance."

The series of 127 drawings of *Jupiter*, made during the year 1876, were forwarded to the "Jupiter Committee" of the Royal Astronomical Society in London, and thence sent to Dr. Oswald Lohse, at Potsdam, for discussion, in order to ascertain whether there be any connection between the changes on *Jupiter* and those on the sun.

A series of twenty-five large astronomical drawings, intended for the use of schools and colleges, is now in process of preparation, and will soon be issued by Messrs. J. H. Bufford's Sons, of Boston, who have reproduced in chromo the best of the drawings exhibited at Philadelphia.

The numerous drawings of *Mars* obtained during the favorable opposition of the present year will enable me to perfect the map of *Mars*, or at least that of its southern hemisphere.

During the next year it is intended to continue observations on the physical appearance of the sun, etc. *Mars* will be followed as long as possible for the study of its climatology. *Saturn* will be closely watched for the phenomena exhibited at the disappearance of the ring. The study of *Jupiter*, commenced two years ago, will be continued. The study of the moon will also be continued, with a view to make the needed corrections to its existing maps, and with the intention to give at some future time a general view of our satellite as it appears at the most favorable moments. The study and delineation of the clusters and nebulæ will be continued, with the hope that, some day, means of publishing the results will be found.

Dearborn Observatory, Chicago, Ill.

——— ———, Director.

In reply to your circular requesting information in regard to the work, etc., of the Dearborn Observatory, I beg to say: Since July of the present year I have been using (unofficially) the 18½-inch

Refractor in double-star observations. Up to this time I have discovered and measured over 100 new pairs, most of them difficult and interesting objects. The list embraces a number of prominent stars: 8 *Andromedæ*, 51 *Cygni*, 47 *Tauri*, 38 *Persei*, *Aldebaran*, etc. Also several of the pairs already known have been found to be triple, as Nos. 17, 171, 366, 2287, 2342, and 2579 of Struve; OΣ 336, OΣ (app.) 220, etc. The larger part of the time has been given to micrometrical measurements of the most difficult of pairs already catalogued, special attention being paid to pairs supposed to be now single, or too close to measure with ordinary apertures; and very unequal pairs and doubles generally, which have not been measured since Struve, or within the last twenty or thirty years. The field in these directions is large, and the results obtained will in the end, I think, be more valuable than measures of the recognized binaries and other familiar objects, certain to be attended to by other observers. I expect to follow up this work vigorously during the coming year. No other use is being made of the telescope. It is admirably adapted to this class of work, and probably superior to any instrument in the world, except the Washington 26-inch.

(Signed) S. W. BURNHAM.

Cincinnati Observatory, Mount Lookout, Ohio.

Professor O. STONE, Director.

1st. *Personnel.*—There is no regularly paid assistant. The director has been greatly aided, however, by two of his pupils, Messrs. Herbert A. Howe, and Winslow Upton.

2d. *Instruments.*—The only large instrument is a *Munich Refractor*, of 28 centimeters clear aperture. The object-glass of this was refigured, and a new *Driving-clock* attached in December, 1874, by ALVAN CLARK AND SONS. The observatory is also supplied with a number of subsidiary instruments.

3d. *Observations.*—Principally the observation of double stars between 0° and 40° south declination. Incidentally a number of new doubles have been detected. A few miscellaneous observations have also been made.

4th. *Publications during* 1877.—1. Catalogue of New Double Stars discovered by Mr. H. A. Howe. 2. Micrometrical Measurement of Double Stars, made by Professor O. M. Mitchel in 1846–8, at the observatory on Mount Adams. 3. Micrometrical Measurement of Double Stars, made in 1875–6, at Mount Lookout (new observatory).

Pennsylvania College Observatory, Gettysburg, Pa.

Professor PHILIP M. BIKLÉ, Director.

Our observatory is used almost entirely for the general purposes of class-instruction. Like many others, I am so burdened with the

duties of teaching that I have little or no time for special work; and even if I had, we are not yet equipped fully enough for pursuing any special investigations. I look forward, however, to some special work in the direction of solar physics.

Our principal instruments are an *Equatorial Telescope*, with a 6.4-inch object-glass, 9 feet focal length; a *Transit Instrument*, with 2.2-inch object-glass and 30 inches focal length; a *Negus Break-circuit Chronometer;* and meteorological instruments.

Our work has been confined almost entirely to keeping correct *time*, and to the usual meteorological observations. The only publication during the year was a pamphlet of 36 pp., by myself, on "Our Present Knowledge of the Sun."

Morrison Observatory, Glasgow, Mo.

Professor C. W. PRITCHETT, Director.

The Morrison Observatory was founded at my request, in connection with Pritchett School Institute, by Miss Berenice Morrison. She has already donated to the observatory $50,000, and an equal sum to Pritchett School Institute. I am now assisted by my son, Henry S. Pritchett.

The observatory building has an eligible site half a mile east of the college, and was completed in 1876. It has a front on the south of sixty-five feet. On the east is the Equatorial Room, of brick, circular on the inside. The entire dome, twenty-four feet in diameter, is easily revolved by a moderate pressure of the hand on a system of wheel-work. The circular shutters are in four sections, and are readily raised or lowered by a system of gearing, working two pairs of endless chains. The centre of the pier for the Equatorial is twenty inches south of the centre of the dome, so as to bring the centre of motion of the instrument to the centre of the sphere.

The Transit Room—a strong frame building—is directly west of the Equatorial.

The Library and Work Room is directly west of the Transit Room, and is separated from it by a hall.

Instruments.—The *Equatorial*, by ALVAN CLARK AND SONS, was mounted in December, 1875. The objective is 12¼ inches in aperture, and focal length 17 feet. It is furnished with *Finder*, *Automatic Movement* (very simple and regular), *Filar-position Micrometer*, and a range of power from 50 to 1200. Its cost in the shop was $6000 in gold. Its performance has proved very satisfactory.

Transit Circle, by TROUGHTON AND SIMMS, of London, was mounted in June, 1877. The objective is 6 inches, and focal length 82 inches. Its style of mounting is similar to that of the new Transit Circle of Harvard College Observatory.

Work of Last Year.—Unfinished as the observatory was, work was done during the year 1876 as follows:

1. Regular time-observations were made.
2. Meteorological records were made three times each day.
3. Many occultations of stars were observed, and applied to the determination of the longitude.
4. Satellites of *Saturn* (3, 4, 5, 6) were specially observed from September till January.
5. Much work was bestowed on the great nebula in *Orion* in the latter part of the year.
6. Many close double stars were observed by position-angle and angular distance.
7. Popular observations of the moon, planets, nebulæ, clusters, and double stars were very numerous, to meet the demands of visitors.

The observations on the Equatorial during the present year have been—micrometric measures on close double stars and diameters of planets, and position-angle and distance of satellites. Recently the new satellites of *Mars* have been often observed. We are also continuing observations on satellites of *Saturn*. We have published our observations on these satellites.

Arrangements are in progress to determine our longitude by clock-signals with the United States Naval Observatory. Our position, as already *approximately* determined, is: Lat. 39° 16′ 17.5″ N., long. $6^h\ 11^m\ 10^s$ W. of Greenwich.

Private Observatory, Hartford, Conn.

D. W. Edgecomb, Director.

This consists of a small framed building, with revolving dome 12 feet 6 inches in diameter. It contains a *Telescope*, by Alvan Clark and Sons, with object-glass 9.4 inches clear aperture, mounted equatorially in the best manner. The instrument is used by its owner in general observations of the moon, planets, and double stars, other occupations preventing at present any more systematic work. The object-glass is one of Mr. Alvan Clark's latest works, and is of the highest excellence, exhibiting objects generally considered tests for 12 inches.

The outer satellite of *Mars* was observed on two occasions after the announcement of Professor Hall's discovery. An observation of the bright spot which appeared upon *Saturn* in December, 1876, was used by Hall in his determination of the rotation period of that planet, and some new double stars have been found with this instrument.

Dr. Henry Draper's Observatory, Hastings-on-Hudson, N. Y.

Dr. Henry Draper, Director.

In answer to your letter of inquiry in regard to my observatory at Hastings-on-Hudson—1st. My wife is my assistant. 2d. The principal instruments are a *Silvered-glass Reflector*, of 28 inches aperture, mounted equatorially; an Alvan Clark *Refractor*, of 12 inches aperture, mounted equatorially; a 15½-inch *Silvered-glass Reflector*, mounted as an alt-azimuth; a 2-inch *Transit Instrument; Clock; Chronometer;* and *Chronograph*. 3d. My principal work during the past year has been spectroscopic photography, which has led me to the discovery of oxygen in the sun. 4th. The same line of work will be pursued during the coming year, as the observatory is fitted with a complete electric apparatus for spectrum photography, consisting of an engine, Gramme machine, 18-inch Ruhmkorff coil, etc.

I have published in *Silliman's Journal* the results of an examination of the astronomical conditions of the atmosphere of the Rocky Mountains, made during the past summer. On the whole, the conclusions are that the *steadiness* of the telescopic images is less than at New York, while the *transparency* of the air is much greater at the higher elevations.

Observatory of Yale College, New Haven, Conn.

Professor C. A. Lyman, Director.

This observatory is intended chiefly for use as a means of instruction in connection with the classes in astronomy taught in the college. There is no endowment for other purposes. During the past year it has been in charge of Mr. H. A. Hazen and Mr. Wm. Beebe.

Instruments.—Equatorial, 8¾ inches; *Altitude* and *Azimuth Instrument*, 4 inches; besides smaller instruments; two *Sidereal Clocks* and a *Sidereal Chronometer; Sextants*, etc.

A full series of observations on comets *b*, *c*, and *f*, and a few on *e*, have been made, and partially published.

Princeton College Observatory, Princeton, N. J.

Professor C. A. Young, Director.

The Halstead Observatory, with its magnificent dome (nearly forty feet in diameter), does not at present possess an instrument; but it is hoped that within a short time the deficiency will be supplied.

A small observatory, for purposes of instruction, is just completed after the plans of Professor Young, the funds being supplied for its

equipment by the trustees of the estate of the late John C. Green, who founded the School of Science.

The building is of wood, this material being chosen for the purpose of allowing the temperature of the outside and inside air to be rapidly equalized. To prevent danger from fire, all the lights are from fixed gas-jets fitted with Bogart's automatic electrical apparatus for lighting.

The dome is 18 feet in diameter, and is provided with a fine *Equatorial*, by CLARK, of 9½ inches aperture and about 12 feet focal length. The Gaussian curves are used in the construction of the object-glass, and the two lenses are so mounted that the distance between them can be adjusted so as to give whatever chromatic correction may best suit the work in hand, whether visual, spectroscopic, or photographic.

The instrument is provided with all the usual micrometric accessories, and with a *Single Prism-spectroscope* by CLARK, which is also adapted to the use of diffraction gratings. Of these there are three, with lines 1¾ inches long, the ruled space being 2 inches in width, prepared expressly for this instrument by Mr. CHAPMAN with Mr. Rutherfurd's machine. There is also a powerful compound *Spectroscope*, by GRUBB, and there are the necessary electrical appliances.

In the meridian three instruments are, or rather are to be, mounted in separate rooms.

The *Meridian Circle* is in process of construction by FAUTH, of Washington. Its telescope will have an aperture of 4 inches, and its circles will be 2 feet in diameter, reading by four microscopes. It will be provided with collimators, reversing apparatus, and apparatus for examination of pivots. It will be mainly on the plan of the instrument at the Harvard College Observatory, and will in all points be a very complete and perfect instrument for purposes of instruction.

In the adjoining room is mounted a "broken" *Transit*, by KAHLER, of Washington. It has an aperture of 2¾ inches, with a focal length of 30 inches; is fitted with a reversing apparatus, with the necessary level and micrometer for latitude determinations, and with a pair of collimators.

In a third room are mounted a small *Transit Instrument*, of about 1¾ inches aperture, and a *Universal Instrument*, with 8-inch circles, by BUFF AND BERGER, of Boston.

In the prime-vertical is mounted the AYCRIGG *Transit*, of 3 inches aperture and 3 feet focus. It has an iron stand and reversing apparatus, by STACKPOLE, of New York.

At the junction of the two wings a room is formed which contains a lift by which portable instruments may be taken up to the roof, and used upon a platform, which is detached from the building and

secure against vibrations. The instruments to be used in this way are a 9¼-inch *Silvered-glass Reflector*, by BROWNING; a *Comet-seeker*, of 6 inches aperture, by FITZ, and a 3-inch *Telescope*, by FRAUNHOFER.

The time is furnished by two standard *Clocks* (one *Solar* and one *Sidereal*), and by 5 subsidiary *Clocks* electrically controlled by the standard Sidereal, one in each of the observing-rooms. The Clocks are by HOWARD & Co., of Boston, and the Sidereal standard has the new escapement invented by Professor YOUNG. Both this and the Solar Clock have a modification of ROBINSON's barometric compensation.

The *Chronograph*, by CLARK, has three independent cylinders. This and the standard Clocks are mounted in a room which is heated in cold weather. The cost of the whole was about $23,000.

The building and its equipment will be used mainly for the purpose of teaching practical astronomy to select classes. Its equipment is such, however, that it will be possible to do some real astronomical work in the way of determining star positions with the Circle, observing occultations and similar phenomena, measuring double stars, and especially in keeping up a series of solar observations, ocular, spectroscopic, and photographic.

Experience only, however, can determine how much of this work will be practicable without interfering with the work of instruction, which will always hold the first place.

At present Professor Young is without assistants; but it is hoped that before long the want will be provided for, either by persons specially appointed or by post-graduate students.

Observatory of Quebec.

Commander E. D. ASHE, R.N., Director.

1st. The *personnel* consists of myself and assistant.

2d. Two *Clocks*—a *Sidereal* one, by DENT, and a *Meantime* one, by MOLYNEUX; a 36-inch *Transit*, mounted between stone piers; and a splendid *Equatorial*, of 8 inches clear aperture and 9 feet focus, by ALVAN CLARK; a 42-inch *Telescope*, by DOLLAND.

The principal object of the observatory is to give time to the shipping by dropping a ball at one o'clock, showing $5^h\ 44^m\ 49^s$ *Greenwich time.* Besides this, I have been very successful in solar photography. There will be no alteration in the observations during the next year.

Observatory of Ripon College, Wisconsin.

Professor C. A. KENASTON, Director.

This observatory contains a fine *Transit Instrument*, a MITCHELL *Chronograph*, and a good *Astronomical Clock*.

Rochester Observatory, Rochester, N. Y.

Professor LEWIS SWIFT, Director.

My *Telescope* is a 4½-inch achromatic, and was equatorially mounted; but being at present without an observatory, I have changed it to an alt-azimuth, as being much more convenient for comet-seeking. For the past one and a half years I have done my observing—comet-seeking a specialty—from the flat roof of an elevated building commanding in every direction an unobstructed horizon.

Arrangements are pending for a regularly equipped observatory, with probably a 9-inch *Telescope*, *Micrometer*, *Driving-clock*, etc. The line of study will be, as heretofore, comet-seeking and the formation of a chart of all nebulæ visible through a telescope of 5 inches aperture. For many years I have seriously felt the want of such a chart. I shall construct it for the especial benefit of comet-seekers.

The result of the year has been the discovery of comet *c*, and observations of comets *a*, *b*, *e*, and *f*. Comet *d*, "D'Arrest's," with all my efforts, I was unable to find from excessive faintness.

The secondary tail to comet *b* I discovered, and published a description of it in our city papers, long before I heard of its discovery in Europe.

Office of "The James Lick Trust."

The specific information that you request we are unable to give, as the construction of the Lick Observatory has not been actually begun.

I am instructed, however, by the president of the trustees to endeavor to give you such information concerning the proposed observatory as might prove of interest.

Mr. Lick reserved in his deed of trust the right to himself determine the site of the observatory, and, after long consideration of various other points in California proposed, finally selected the summit of Mount Hamilton, situate in the county of Santa Clara and about thirteen miles east of the city of San José (in a direct line).

In consideration of this selection, the county of Santa Clara agreed to assume the expense of constructing a suitable road from San José to the observatory site, which is now completed.

By said road the distance from San José to the summit is about twenty-five miles. From San Francisco to San José the distance is a little less than fifty miles by railroad, with two lines available.

The summit of Mount Hamilton is elevated above the sea about 4250 feet, and in point of atmospheric conditions favorable for an observatory is, so far as appears from present information, probably

as good as the summit of any other mountain in the California coast range of equal elevation.

It has not yet been decided whether, in attempting to construct an instrument "superior to and more powerful than any telescope ever yet made," the better success would be promised by attempting a great reflector or a great refractor. The opinions of many distinguished astronomers, as far as we have yet learned, seem to be divided on this question.

The nature of the site of the observatory will perhaps enter as one of the many important considerations in determining the kind of instrument.

Work will not be commenced, nor will any steps be taken towards contracting for the great telescope, until the claims of Mr. Lick's heirs against his estate are settled by the suits now pending in our courts.

The heirs have offered a compromise for $383,000, which all of the various beneficiaries have agreed it advisable to accept; but the California Academy of Sciences have demurred to the proposition to pay the compromise-money from the residuum of the estate after all the specific bequests have been paid in full (they being, with the Society of California Pioneers, the residuary legatees), and are now contending in court for a *pro rata* payment of the compromise-money —to wit, that all the bequests be adjudged liable to provide their *pro rata* of the amount necessary to complete the compromise.

The trustees hope soon to get a decision of the court which will finally settle this matter, and enable them to begin carrying out the various objects of Mr. Lick's donations.

I have mailed you such printed matter as I could furnish to aid you in determining for yourself if there is any matter of interest for your purpose. I am, yours, respectfully,

H. E. Mathews, Secretary.

Lehigh University Observatory, South Bethlehem, Pa.

Professor C. L. Doolittle, Director.

The observatory was founded by Robert Sayre, of this place, and is known as the Sayre Observatory.

It was built primarily with a view to furnishing facilities for instruction in astronomy to students of the university. Since my connection with the institution, I have been engaged, as far as my other duties would permit, in making and reducing the following series of observations:

1st. Determination of longitude of observatory. Signals were exchanged with the Washington Observatory on six evenings for this purpose, a preliminary reduction of which gives our longitude $6^m\ 40.3^s$ (South Bethlehem) E. of Washington. A final reduction may change this slightly.

2d. A series of 450 observations with zenith telescope, for latitude, made on sixty pairs of stars. A preliminary determination of the latitude from 182 of these observations gives 40° 36′ 23.75″ N.

3d. A series of micrometrical measurements of the position of *Mars* during the recent opposition for parallax determination.

It is intended to publish the foregoing in the form of a pamphlet, which, I hope, will appear before the end of 1877.

There is no especial provision given for regular astronomical work. Such as I undertake is on my own responsibility, and in addition to the work of instruction. The only assistance in that direction is such as I can get from my pupils.

Our instruments are: A 6-inch *Equatorial*, by ALVAN CLARK AND SONS; a *Zenith Telescope*, by BLUNT; a *Field Transit*, by STACKPOLE; a *Sidereal Clock*, by BOND AND SONS.

Observatory of Vassar College.

Miss MARIA MITCHELL, Director.

First. The *personnel* of the observatory is confined to myself. I have the aid, however (and it is often very valuable), of volunteer work by my students.

Second. The instruments of the observatory are: An *Equatorial Telescope*, of 13½ inches aperture, the glass of which has been reground by ALVAN CLARK, and is very good; a *Meridian Instrument*, by YOUNG, of Philadelphia, the aperture 3¾ inches (adapted to this are two *Collimating Telescopes*, by CLARK AND SONS, of Cambridge); a *Sidereal Clock* and *Chronograph*, by BOND AND SONS, Boston. The observatory has also the use of several portable telescopes, photographic apparatus, etc., but they are private property.

Third. Photographs of the sun are taken every fine day, and have been for several years.

Observations with the Equatorial are made on the planets *Jupiter* and *Saturn*, with measurements, whenever the weather is suitable.

Observations for Time.—These observations it is proposed to continue during the coming year.

Hopkins Observatory, Williams College, Williamstown, Mass.

Professor T. H. SAFFORD, Director.

The *personnel* of this observatory consists of the director and two students.

The main instruments are a 7½-inch CLARK *Equatorial*, of ancient date, and a 3½-inch SIMMS *Transit*, with *Clock*, by MOLYNEUX AND COPE. Observations for a year past have been such as were needed for teaching the undergraduates and making myself acquainted with

the instruments and their capacity. My intention is to observe right ascensions of certain stars with the present Transit, and, if practicable, to get a better Meridian Instrument and pursue the observation of the zone 35° to 40°, undertaken at Chicago.

My leisure is rather limited. I am professor of physics and astronomy, and am printing two volumes: (1) Observations of right ascension, about 15,000 in number, made at Cambridge in 1862–65 by several observers (about half my own), on a plan arranged between Professor G. P. Bond and myself. The stars are largely those near the pole, and contribute to my general plan of work. (2) A compiled catalogue of 2018 latitude stars, for Lieut. Wheeler, U.S.E. Modern authorities are utilized, including many scattered series by Bessel, Gauss, Argelander, Struve, and others, which have mostly escaped notice because used in special memoirs on latitude. My last publications, with one exception, treat of the solar motion as connected with the stars' proper motions and distances; and the observations of the next year will bear on this subject.

My present working list contains nearly 400 stars. These are such as occur in the two books above mentioned and need reobservation; mostly those which exhibit a decided proper motion not yet determined with accuracy; in many cases wrongly given elsewhere.

PHYSICS OF THE GLOBE.

By CLEVELAND ABBE,
OF THE WEATHER BUREAU, WASHINGTON, D. C.

THE EARTH.

INTERNAL CONDITION.

The remarkable address of Sir William Thomson at the Glasgow meeting of the B. A. A. S. in 1876, in which he renounced the views so long entertained by him as to the internal fluidity of the earth, and gave in his adherence to Hopkins's conclusion as to its solidity, has been followed by a paper by Gen. J. G. Barnard, in which he differs from some of the points taken by Thomson.

INTERNAL TEMPERATURE.

In reference to temperatures observed deep within the earth, Mr. Oswald Foster has communicated to the Cambridge Philosophical Society a memoir in which he maintains that the abnormal temperatures observed in the artesian well 4000 feet deep at Sperenberg might be accounted for by vertical currents, while the average rate of increase is 1° Fahr. for every sixty feet of descent.

The very delicate and exact and convenient method of observing temperatures at points underground, or otherwise of difficult access, by means of the so-called electro-thermometer, as used by Becquerel at Paris, deserves to be introduced at some of the physical laboratories of America. Observations have been made daily for many years at Paris, the results of which have lately been communicated to the Academy of Sciences.

VOLCANOES.

Of general work on vulcanicity we make especial mention of the investigations of Mr. G. K. Gilbert, of Powell's Geological Survey of the Western Territories, who by the study of peculiar formations among the Henry Mountains, of Utah,

has revealed an entirely new type of volcanic eruption, in which the lavas, instead of finding vent at the surface of the ground, ceased to rise while still several thousands of feet under ground, and lifted the superincumbent strata so as to make for themselves deep-seated subterranean reservoirs, within which they congealed, to be revealed only after the erosions of subsequent ages. The volcanoes of Iceland have been investigated by Professor Johnstrup, whose report is published by the Danish government.

EARTHQUAKES.

A violent earthquake occurred at 8.30 P.M. May 9th on the southern coast of Bolivia and Peru, destroying many small towns. It was central near Iquique, and was accompanied by an oceanic wave about sixty-five feet high at the central stations. This wave reached San Luis Obispo and Honolulu simultaneously at about 5 A.M. of the 10th (Honolulu time), doing much damage in the Sandwich Islands, where much activity had been previously observed in the volcanoes (see *Monthly Weather Review*, May; *Am. Journal of Science;* and Petermann's *Mittheilungen*, Dec. 1877).

A new electric seismograph of much completeness has been invented by Secchi. Some such instrument is much to be desired for use on our Pacific coast.

TERRESTRIAL MAGNETISM.

An interesting memoir is published by Wijkander on magnetic perturbations and their connection with the aurora borealis. This is mainly an historical introduction to the important observations published by the Swedish expedition to Spitzbergen in 1872–73. The connection was first noted by Celsius and Hjorter (1741) in Sweden, at whose request Graham (1761), in England, made corresponding observations, so that the simultaneity of the phenomena was at once revealed. The Swedish expedition has established the fact that the magnetic disturbances which attend an aurora have their origin, or act as if they originated, at points on a zone that extends from British America northeast to North Cape and then around the globe, apparently not far from the zone of greatest auroral frequency as established by Loomis or Fritz. The cause of these disturbances is to be looked for

in the existence of abnormal electric currents produced near the earth's surface by some change in atmospheric conditions. These disturbances are themselves subject to daily and annual fluctuations; they are of a general and of a local nature, and can be detected instantly by simultaneous observations at several distant and several neighboring stations. The connection between the aurora and these disturbances in the magnetic instruments is of a secondary nature to the connection between the latter and the telluric electric currents. Since the lesser magnetic disturbances are almost continually occurring, the traces of aurora are also almost as frequent. (This agrees with the inference fairly deducible from the numerous auroras recorded in the *Monthly Weather Reviews* of the Army Signal Office.)

The magnetic survey of Russia during 1871–75 by J. Smirnow has been published in a translation from the original Russian. Smirnow gives a comparison with Sabine's charts, and shows where observations are now or soon will be most needed.

Hann contributes an instructive review and comparison of the diurnal and annual periods in the magnetic declination at Russian and Australian stations.

"The Absolute Direction and Intensity of the Earth's Magnetic Force at Bombay, and its Secular and Annual Variations," by Ch. Chambers, gives the result of magnetic observations at Bombay since 1867. The magnetic elements are all progressing in the positive direction.

The Coast Survey Report for 1874, published during this year, contains valuable memoirs by Schott on secular change of magnetic declination in the United States, and a discussion of the results of the self-recording instruments at Key West, 1860–1866.

EARTH CURRENTS.

At a recent social meeting of the London Society of Telegraph Engineers, Mr. Saunders, of the Eastern Telegraph Company, exhibited some diagrams showing some results of simultaneous observations of the earth currents observed at both ends of the broken cable between Suez and Aden. A striking coincidence is seen between the currents observed on the two sections of the cable.

THE OCEAN.

DENSITY, ETC.

Mohn contributes to Petermann's *Mittheilungen* a memoir on the temperature of the Atlantic east of Greenland. He shows that a belt of warm water extends northeastward to beyond the North Cape. This belt moves eastward in summer and westward in winter. He also accurately defines the limits of the bottom stratum of cold water at maximum density, and shows how it is limited by the configuration of the sea bottom.

Schmidt, of Dorpat, has extended his memoir on the salinity of natural waters to the ocean and salt seas, and in a comprehensive table gives the results of all known observations.

TIDES.

The tidal observations made by the English Polar Expedition of 1876 have been reduced by Professor Haughton, and in a preliminary account of his results read before the British Association, he stated that the results obtained by Dr. Bessels from the *Polaris* expedition were confirmed by the English expedition, viz., that there was a junction of two important tides in the largest portion of Smith's Sound. A new type of tide had been found confirming Dr. Bessels' reasoning to show that Greenland is an island.

At the same meeting of the B. A. A. S., papers "On the Tides of Port Louis and of Freemantle" were read by Sir William Thomson, and "On Solutions of Laplace's Tidal Equation for certain Special Types of Oscillation."

WAVES.

Forel, of Morges, on the north shore of Lake Geneva, has from the study of the self-recording tide-gauge of large scale shown that the surface of the lake oscillates rhythmically in fixed periods about two axes, *i. e.*, the longest and shortest diameters of the lake. The times of vibration are respectively seventy and ten minutes.

Numerous notices have appeared in the *Monthly Weather Review* of remarkable fluctuations in the waters of our Great Lakes. These, however, appear mostly to be due to earthquakes, and have as yet never been shown to have any such

regularity as Forel finds for Lake Geneva, although possibly such may be revealed by self-recording instruments.

The oscillograph is the name given by Bertin to an apparatus for recording continuously the rolling and pitching of a vessel at sea. The apparatus has been lately extensively used in the French navy, and affords important data both for ship-builders and for students of wave motion. It is also applicable to the determination of that correction to an anemometer record on shipboard needed in order to obtain the correct velocity of the wind at sea.

An important paper on the progression of waves was read by Osborne Reynolds at the Plymouth meeting of the B. A. A. S., and an equally important one by Lord Rayleigh on the same subject was presented to the Mathematical Society in November.

THE ATMOSPHERE.

INTRODUCTORY.

The following brief notice of the scientific activity of the year in the department of meteorology brings our record down to the last of December; and, however imperfect it may be, yet suffices to show that but few preceding years have been marked by more important events. Among these latter we would place the extension of the United States network of meteorological observers over the elevated regions west of the plains of the northwest and southwest, the extension of its system of international simultaneous observations to the vessels of the United States Navy and the United States, British, and German merchant marine; the publication of several volumes by the new India Meteorological Office under Blanford; the works of Brault on the winds of the Atlantic; those of Guldberg and Mohn on the mechanical laws that pervade the cyclonic and anticyclonic areas of wind and pressure; and the elegant memoir of Ferrel on the general circulation of the atmosphere, with accompanying polar charts of isotherms and isobars.

INSTITUTIONS AND PERSONS.

The Army Signal Office, although somewhat hindered by a diminution of its quota of men, has continued its labors

with increasing industry. Its usefulness as a medium of direct communication with all parts of the country was singularly apparent and highly appreciated by the President during the riots of August. A series of novel and very elementary, yet practical, stations has been established, wherever telegraph lines penetrate into the Rocky Mountains and Sierra regions, and from these as well as from all other stations reports of the appearance of the sky at sunset are sent daily to the Washington Office. The number of foreign stations and ships reporting simultaneous observations on its plan of international exchange has now increased to about 375, to which the United States adds 80, with the promise of more land stations. Daily weather maps for the whole northern hemisphere are now compiled daily by this Bureau.

The preliminary expedition in pursuance of Captain Howgate's plan of Polar colonization sailed for the North in August, and was accompanied by Mr. O. T. Sherman, a graduate of Yale College, as meteorologist. A supply of all necessary apparatus was taken, and we may expect a full record of observations. Among the novelties we may mention the supply of a number of small balloons for the determination of currents of air and of the heights of the clouds according to the methods recently used in Paris by Fonvielle and Secretan.

The Permanent Committee of the Vienna Congress has published the report of its meeting at London in 1876, in continuation of its reports of the meetings at Vienna, 1873, and Utrecht, 1874. A mass of information is given in reference to the various practices of observers in regard to instruments and methods, and the way prepared to a greater uniformity in these matters. The unpublished data now in the hands of European offices, and the investigations in progress or needed, are also put on record.

Of the publications of the Physical Observatory at St. Petersburg we have received only the valuable but rather cutting *brochures* of Wild on the accuracy of standard barometers and on the accuracy of modern anemometry. Doubtless the regular annual volumes have been somewhat delayed in transit. The second part of Volume V. of the *Repertorium*, and a supplementary part, were published in September. (See CLIMATE.)

The Dorpat Meteorological Observatory has published the "Met. Beob., 1875," completing the lustrum 1870–75, and also "Zehnjährige Mittelwerthe, 1866–75, nebst neunjährige Stundenmitteln, 1867–75," forming the Appendix to Volume II. of the Dorpat Observations. The authors, Professors A. von Oettingen and K. Weihrauch, have spent great labor upon the discussion of these excellent observations, especially those of the wind. The volume also includes observations made at Reo, in the island of Oesel.

The first annual report (1875) of the Meteorology of India, by Blanford, marks a long-hoped-for epoch in the history of the progress of our knowledge of that portion of the world. Hitherto the Indian observations have been strewn through numerous transactions and miscellaneous volumes, but now the establishment of a central office will do much to concentrate effort and increase knowledge. Blanford's folio volume, of 387 pp., contains a highly instructive review of the physical peculiarities of India, and especially of the meteorological stations. These latter are classified as first class, 2; second class, 21; third class, 65; and rainfall stations, 198. Not only are means, etc., given for 1875, but for many long series of observations; so that the volume is in some respects a summary of the past previous to the start on the new career now opening before him.

A very fine feature of the India Office is the publication of "Indian Meteorological Memoirs," a volume similar to Wild's *Repertorium*, and containing the results of the investigations made by the Calcutta Office. Of these memoirs, Vol. I., Part I., containing three memoirs by Blanford, is published simultaneously with the "Observations."*

The climate of South Australia is well described, both popularly and scientifically, by Charles Todd, of Adelaide, in "The Observatory and Climate of South Australia." Mr. Todd, as Meteorological Reporter, has been able to make good use of the telegraph lines of Australia, over which he

* Jan. 25, 1878. We cannot refrain as we go to press from calling attention to Blanford's Part II. of the "Meteorologists' Vade Mecum," which is just received, and is simply an elementary treatise on meteorology as exemplified in the climate of India. In this work all the errors that still disfigure our text-books are dropped, scarcely mentioned, and the best thoughts of the best men of 1877 are clearly set forth.

has control, being Superintendent of the Post-office and Telegraph Lines. There report to him daily by telegraph a number of rain and weather stations, and in the volume above named he gives the means and sums for 70 stations out of the 80 that he has established. Russell, at Sydney, also publishes a daily telegraphic weather bulletin.

The French Meteorological Association has begun the publication of a semi-monthly, *La Quinzaine Météorologique*, giving for fifteen or twenty stations the daily observations and general weather notes. Possibly this may develop into something equivalent to the *Monthly Weather Review* of the Signal Office, a publication that has already been copied from by the Berlin and the Toronto weather offices.

Professor Ragona, of Modena, has issued a circular calling for the formation of an Italian meteorological association. This is done at the request and with the support of very many Italian scientists, and the new society will undoubtedly be a most active and efficient body.

In the highest portion of the upper valley of the "Kleinen Fleiss," a branch of the "Möllthal" in Upper Carinthia, there have existed from ancient times gold and silver mines more than 8000 Paris feet above the sea. Here upon the Goldzeche Fleiss, at an altitude of 2740 meters, was established in August, 1870, a meteorological station, which, as yet, remains the highest in the world—Pike's Peak only excepted. This station is in the midst of the lesser Fleiss glacier, and a brief discussion of the results of the meteorological observations for six years is given by Hann in the *Zeitschrift* of the Austrian Meteorological Association.

The report of the Treasury Committee at London upon the working of the British Meteorological Office recommended that ocean meteorology be transferred to the Admiralty, that the annual grant be increased, and that some aid be given to scientific investigations, as also to the Scottish Meteorological Society; also that the Council in future assume more entirely the control of the office. The report makes a Blue-book of 216 pages, the whole thoroughly indexed, and forming a valuable *résumé* of the present state of practical meteorology in England. The very voluminous evidence published by the committee shows that unfortunately none of those whom they consulted entertain any enlarged or ad-

vanced views of meteorology as a dynamical or physical study. In this respect, possibly, the evidence of Professor Airy is most interesting. He testifies that, in his opinion, meteorology cannot be called a science, because as yet we have scarcely taken a step from causes to effects; that, in order to develop the science proper, there are needed more observations from more numerous stations throughout the world, by means of which to construct daily weather maps. He also points out the necessity of studying the viscosity of the air, the diffusion of vapor, the radiation of heat, and other physical properties which require experimental investigations; that, in short, what we want is a theory to apply to what we observe in the atmosphere. Had the Treasury Committee called to their councils some other witnesses than those they did, they could easily have been furnished with those well-established theories that are now recognized as the basis of the true deductive science. We have ourselves for some years past urged the establishment among our American colleges of special schools and physical laboratories devoted to meteorology. These should, on the one hand, train up the experts needed as advisers to large business interests and in the Army Signal Office, and, on the other, should contribute to the development of that deductive science concerning which so little seems to be known by the witnesses who testified before the Treasury Committee, but which is none the less recognized by most of those who actually make the official weather predictions in Europe and America.

In accordance with these recommendations the London Office is now somewhat differently organized, being directly under the control of the Meteorological Committee, to which Mr. Scott is now appointed as secretary. The report just published for the previous sixteen months shows, however, but little evidence of change. Its sphere of work is somewhat increased.

In Mexico, under the Department of Public Works, a Meteorological Bureau has been established, and hourly observations are published in monthly sheets. Señor Barcena hopes that eventually weather reports and warnings will be exchanged with the United States to the advantage of both parties.

The Royal Academy of Copenhagen has published the valuable meteorological observations of the famous astronomer Tycho Brahe. The record extends over sixteen years (1582 to 1597), and enumerates seventy-eight auroras; it has been carefully analyzed by De la Cour.

The Paris Observatory has published the *Atlas Météorologique des Orages* for 1875. This series of annual volumes now embraces some of the most admirable memoirs that we possess on subjects relating to thunder-storms.

The Observatory at Sydney, Australia, has during the year published a daily weather map, based, of course, on telegraphic reports, and which may be expected to be the precursor of a general map for Australia.

The director of the Paris Observatory seems to have taken the right course in encouraging the enterprise of the *New York Herald*, which paper has endeavored to lay all Europe under still further obligations to it by showing that storm predictions are possible for Europe a week in advance. This bold undertaking has been welcomed with considerable popular applause in Great Britain and France; but the more conservative and rational students still continue to doubt the possibility of real success in the undertaking—twenty-five per cent. of successful predictions will hardly overbalance the seventy-five per cent. of failures that a careful examination of the weather maps has revealed.

When in 1868 the writer started the *Daily Weather Bulletin* of the Cincinnati Observatory, with its local predictions, the proposition to furnish daily synopses to Leverrier was gladly accepted by him, and a greater familiarity with the subject, while serving to show the difficulties, has also impressed him with the possibilities. A simple synopsis of existing conditions on our side of the Atlantic would be a decided help to the European students in their daily predictions.

Since the death of Leverrier the advocates of a complete separation of meteorology from the Paris Observatory have made strong efforts to accomplish their aims. Probably nothing will be done that is inconsistent with existing decrees. It seems to be felt in France that meteorology has not made the advance that it should have done.

The rapid extension of weather warnings for agricultural

purposes in France is seen by the fact that 1000 communes will by the end of the first year be in receipt of free daily forewarnings from the Paris Observatory.

Among the newest attempts to investigate the meteorology of the upper strata of the atmosphere, we note the establishment by Secchi of a complete observatory on the summit of Monte Cavo, 2800 feet above the Roman Campagna.

The meteorology of the Libyan Desert forms the subject of the second volume of Rohlf's Expedition. The editor, Dr. Jordan, finds that the diurnal barometric range is unusually large. The daily range of temperature is 24°; the mean relative humidity at 2 P.M. is 17 per cent. Half an inch of rain fell in February—a matter of rare occurrence.

With the 1st of January the weather maps published by the meteorological offices in Germany and Austria have received considerable enlargement and improvements. The daily weather map published at Vienna is for Europe the best that has as yet appeared, being upon a large scale, and very clear in all its details. The Hydrographic Office at Berlin has begun the publication of monthly weather reviews for Europe. Its articles are compiled and signed by well-known meteorologists; and as it appears only a long time after the month to which it refers, its scope and objects are evidently somewhat different from those of the reviews published by our Army Signal Office.

The *Monthly Weather Review* deserves a wider circulation than it appears to have in this country. It consists of ten or twelve pages of text and three maps, and gives in a very condensed review all the matter received by our Weather Bureau within fifteen days after the close of the month.

Perhaps the most interesting event that has occurred of late years to extend our means of studying the storms of the atmosphere consists in the important order issued on Christmas-day, 1876, by the Secretary of the Navy, to the effect that, wherever our vessels may be, there shall every day be made a complete meteorological observation, simultaneously with those made at Washington at 7 h. 35 m. A.M. It is hoped that the other navies of the world will unite in this simultaneous system of weather observation, and that the merchant marine will follow so far as able. These observa-

tions will form an important part of the Bulletin of International Simultaneous Meteorological Observations, to which so many nations contribute, in response to the invitation of General Myer and the advice of the Vienna Meteorological Congress. The British and United States merchant marines have already voluntarily added valuable observations to this Bulletin. The navies of Portugal and France also contribute.

We learn from the *Japan Weekly Mail* that an excellent pamphlet on meteorology has been published by Mr. Joyner, of the Meteorological Department at Tokio, in which he advocates strongly the establishment in Japan of an extended system of observations by carefully trained observers. Such observations have hitherto been made by Mr. M'Vean and Mr. Joyner for the Department of Public Surveys, and by some of the Americans stationed as professors in the other government institutions.

The International Congress of Meteorologists that was appointed to be held in Rome in September having been deferred to September, 1878, the advocates of a series of international Polar expeditions (Messrs. Wilczek and Weyprecht) have widely circulated their programme, detailing the work to be done, which, of course, largely relates to terrestrial physics. It is proposed that each station be occupied one whole year; besides the usual meteorological observations, particular stress is laid upon observations of ice, tides, auroræ, magnetic phenomena, and earth currents.

As these proposed international Polar stations are for purely scientific investigations, and as their plan so perfectly harmonizes with the Howgate plan of an Arctic colony, it is to be hoped that our own government will establish, at least, two such scientific stations—one at Point Barrow, the other to the north of "Hall's Rest."

The sixth annual report of the Superintendent of the Meteorological Service of the Canadian Dominion, presented by Carpmael in the absence of Professor Kingston, shows the continued activity of the office in gathering meteorological observations from the entire northern portion of America. Twenty new rainfall stations have been established in British Columbia; five new complete stations in the northwest territories; eleven in Ontario; two in Manitoba, etc. In

all, 120 stations report to the Central Office. Telegraphic reports are received from stations in the United States and the Dominion sufficient to allow the office to issue its own daily weather predictions and storm warnings independent of those received from the office at Washington. The work of the office for the year has been highly complimented by the Toronto Board of Marine Exchange.

Detailed tables of observations and averages, etc., accompany the report, as in former years, together with short reports from the observatories at Kingston, Quebec, Montreal, and St. John.

Early in 1877 the large volume containing the meteorological and physical observations of the Polaris Arctic Expedition was published by the National Academy of Sciences. As only a very small edition of this volume was printed, we shall give a somewhat extended *résumé* of its contents as soon as Dr. Bessels has published the results of his revision of the work. Among the interesting items that Dr. Bessels announced was the demonstration of the fact that in Smith Sound there meet two opposing tidal waves from the north and south, confirming the theory that Greenland is an island. The same fact is now independently deduced by Rev. Samuel Haughton from the tide observations of the British Polar Expedition, and a deserved tribute should be paid to Dr. Bessels's sagacity.

Some progress has been made in the formation of state meteorological associations in the United States. The first annual report of the Iowa weather stations shows that about ninety observers report to Professor Hinrichs, who in various ways finds opportunity to foster an increasing intelligent interest in the subject of meteorology. The rainfall map for Iowa is published monthly, and is a most praiseworthy contribution. An enthusiastic beginning has been made by Professor Nipher, of St. Louis, who will publish monthly reports of "The Missouri Weather Service."

The first steps have been taken towards the organization of a state system of reports in Illinois. The statistics generally published annually by the regents of the University for New York, and by the Secretary of State for Ohio, together with the data given in the annual reports of various Boards of Public Works, Chambers of Commerce, Boards of Trade,

etc., show that there is a considerable independent activity in weather observation.

INSTRUMENTS AND METHODS.

The application of the thermo-electric pile to the study of terrestrial radiation has been treated of by Frölich in Wild's *Repertorium*. He employed a blackened surface as his normal standard; this was heated to known temperatures, and its effect upon the pile observed. An empirical formula was thus obtained, which gave the temperature of the surface as a function of the movements of the galvanometer needle. The instrumental constants being thus known, the face of the pile is to be turned towards the sky, and the temperature then observed becomes the basis of further computations, whence the mean temperature of the atmosphere and eventually the mean temperature of exterior space may be deduced. As illustrating his results, Frölich deduces for the mean temperature of the atmosphere —17° C. on August 17 and —36° C. on October 23, 1876.

Dr. Buff, of Giessen, describes a method by which he attempts to make the thermo-electric pile an important meteorological instrument. He claims that it enables us to measure the greater part of that portion of the sun's rays which has not yet been converted into sensible heat. Dr. Buff's method of operating consists in exposing both ends of the pile to the temperature of the air when the needle assumes its zero position. The upper end is then exposed to any portion of the sky, when, of course, the needle indicates heat or cold, according to the position of the sun and condition of the sky. If, now, a plate of glass is held as a screen to this exposed end, it cuts off all rays of low refrangibility, and the needle returns partially, but never during the daytime entirely, to its zero. With a perfectly clear sky, and without the glass screen, the radiation of the exposed end caused, for instance, an indication of —50°, but protected by the glass screen an indication of +10°. On another day the blue heavens gave —30°, the glass screen +20°, and the clouds +50°. The ends of the pile are covered with lamp-black, whose radiation is nearly the same as that of the green leaves, and the instrument, therefore, gives a just idea of the range of temperatures to which leaves are subject. It is a

most important instrument to those engaged in investigations bearing on the growth and distribution of plants, as well as to the physical meteorologist.

The importance of knowing the sum total of the temperatures at any place for various meteorological and phænological studies, lends value to the suggestion of Steinecke that clocks uncorrected or anti-corrected for temperature be introduced as a part of the meteorological apparatus. Such clocks or chronometers, called thermo-chronometers, have long been used in longitude determinations and for rating chronometers, and will abundantly answer the required purpose. But for meteorological purposes, self-recording thermometers, in connection with Ausfeld's planimeter, offer every facility for accomplishing the same end cheaper and better. The idea of temperature clocks is also worked up by Mr. F. Stanley in the *Quarterly Journal* of the London Meteorological Society.

Of the numerous precautions to be taken in using the wet-bulb thermometer, we find some account in Marriott's report detailing the results of observations on ten wet and three dry thermometers all enclosed in the same cage. It is necessary that all should be covered with the same kind of muslin, which should be *very thin*, and be connected with the water reservoir by six or eight threads of yarn tied to the upper end of the muslin. For the minute yet important details we must refer to the volume itself.

The formulæ for correction of the instrumental errors of the aneroid are given by Von Wullerstorff Urbain, who exemplifies them by an example drawn from the record of the ship *Tegetthoff*.

In the course of his remarkably accurate investigation into the truth of the Boyle or Mariotte law, Mendelleff invented an improvement upon the barometer—undoubtedly one of the most important that has ever been suggested. It consists simply in terminating the upper end of the barometer tube by a capillary tube bent downward. By means of this it is possible to cut off and expel the last trace of any foreign gas that may remain in the vacuum chamber. He thus obtains a perfect instrument without boiling the mercury in the tube. His determination of the correction for capillarity and his method of measuring the barometric press-

ures are the most refined of modern times. He attains an accuracy of the twenty-five-hundredth part of an inch, in his results rivalling the new normal barometer constructed by Wild.

There have come to hand from the India Office Blanford's pamphlets of Instructions to Observers and Tables for the Use of Observers, both of which correspond in every way with the latest views of meteorologists. We note as to his tables for the psychrometer that Blanford has computed them for barometric pressures of from 29.7 to 18 inches, thus allowing the use at each station of a table adapted to its own altitude. He has also introduced the correction to the tension of vapor for reducing barometric heights to gravity at 45° latitude, a correction that is quite sensible, but ought not to be applied unless all the barometric readings are similarly corrected, as has been done by Ferrel in the isobars on his charts of the earth on a polar projection.

Professor Mendelleff, of St. Petersburg, author of a well-known hand-book of chemistry, has announced his intention to devote to the prosecution of atmospheric studies by means of balloons all the profits of his published works for the next five years. He will probably begin by constructing a captive balloon holding from 50,000 to 70,000 cubic feet of gas.

Some interesting facts deduced from observations made during balloon voyages near Nashville, Tennessee, under the conduct of the well-known aeronaut Professor S. A. King, of Boston, are given in the *Signal Office Monthly Weather Reviews* during the year.

The highly important observations of clouds and currents of wind by means of toy balloons continue to be daily made at Paris, under the patronage of Secretan. No more promising field of research has of late years been opened up to meteorologists, and its economy places it within every one's reach.

Bell's telephone proves to be so exceedingly sensitive to disturbing currents that it is said that the occurrence of a thunder-storm anywhere within the horizon was made evident by a peculiar class of noises—indeed, storms still out of sight have thus preannounced their approach, and it is suggested that this instrument may prove a highly useful addition to the equipment of the meteorological observer.

CONSTITUTION AND PROPERTIES OF THE AIR.

Mr. G. W. Hill, of Nyack, New York, contributes to the July number of the *Analyst* a paper on an empirical formula for the volume of atmospheric air at any temperature and pressure. Starting with the fundamental assumptions (1) that under constant pressure the ratio of volume to temperature is constant, and (2) that the constant ratio is itself a function of the pressure, he shows that Regnault's observations of the volume and tension of air, intended as a test of the law of Boyle and Mariotte, lead to the conclusion that this law is exactly true only at the temperature of 130° C., and that the coefficient of expansion under a constant pressure is 0.0036445 at a pressure of zero, whence it increases up to 0.0038618 at a barometric pressure of 21.5 meters, or about twenty-eight atmospheres.

The carbonic-acid gas in the atmosphere has been observed by Farsky at Tabor in Bohemia, altitude 1400 feet. Daily observations for one year gave a mean value of 3.43 volumes in 10,000, or 0.034 per cent. The quantity of this gas increased with the variability of the weather.

Winkelmann shows that observations lend probability to the theoretical conclusions of Von Obermayer that the coefficients of conduction for heat of air and hydrogen have different and not the same ratios at different temperatures. Similarly Von Obermayer has shown that the coefficient of friction for hydrogen increases with the temperature more slowly than does that for the air. These results are confirmed by a more recent investigation by Pulitz.

The absorption of radiant heat by aqueous vapor has been treated of very well by Haga, who reviews the work of Hoorweg, and concludes that a column of saturated air at 17° or 18° C., one meter long, absorbs 3 per cent.; 3.3 meters long, 10 per cent. of the heat radiated from a Leslie cube at 100° C. Besides these, Buff, of Giessen, has also shown that aqueous vapor is far more, and dry air far less, diathermanous than was maintained by Tyndall. Their results materially effect some meteorological theories.

Lins shows how observations of halos may be utilized to determine the dew-point at high elevations in the air.

Kummer has, in the Berlin *Abhandlungen*, continued his investigations into the resistance of air to projectiles.

TEMPERATURE AND DIATHERMANCY.

Our knowledge of the transparency of our atmosphere is reviewed by Ricco in the *Memoirs* of the Italian Spectroscopic Society; he gives an instructive collation of the coefficients of transmission of the total solar radiation and also the separate coefficients for the purely luminous rays. Some observations made by Provenzali at Rome with the lucimeter are here published for the first time.

Numerous papers relative especially to the diathermancy of the atmosphere have been published in France principally by Crova.

Wielenmann's important memoir of 1872, on the temperature of the atmosphere as deduced from purely geometrical and physical relations, and in which he successfully reproduced the observed hourly temperatures for stations over the whole globe, has now been followed by an almost equally successful deductive treatment of the subject of evaporation and atmospheric moisture. A translation by Freeman of Fourier's "Analytical Theory of Heat" has been published by the Cambridge Press.

Dr. Stilling, in studying the cold period of May, 1876, in Russia, shows that it depended on the formation of barometrical minima, which passed from the Baltic to Southern Europe.

Careful observations and study of the temperature and humidity of the air at different altitudes have been made at Upsala by Professor Hamberg. By means of thermometers attached to high stationary posts, Hamberg has studied the influence of altitude *per se*, while by means of small movable posts he has investigated the influence of the nature of the surface soil. Some of his results are briefly as follows: During clear weather, and at least from two hours before sunrise to two hours before sunset, the temperature of the air is lower than that of the earth on which it rests. The fall in temperature preceding sunset is greater near the earth than at greater heights. The latent heat evolved during the formation of dew arrests the fall in the temperature, but not to the extent that some suppose. After the dew is deposited, the temperature may sink even to below the freezing-point; but as soon as the dew changes to hoar-

frost, the temperature of surrounding air rises to 32° Fahr., and even above, while higher up the strata of air continue to be even below 32°. The isothermal surfaces near the earth during the night are not always horizontal or parallel.

Hellmann, in a memoir on the variability of the temperature in Northern Germany, gives many comparisons of local interest, especially relative to the influence of the Baltic and North Sea.

In an important memoir on the annual temperature period, Ragona first deals with the theoretical formulæ, and then applies them to observations at Modena, Bologna, Milan, and Geneva. He shows that the radiation of heat at night from the earth is proportional to the solar radiation received during the day. Among the many very interesting results of his investigation, he gives formulæ representing the annual changes in the daily maximum and minimum temperatures, and shows that the mean of these two formulæ represents the mean annual temperature.

WINDS AND CURRENTS.

Anything that draws the attention of observers to the importance of observing the actual heights and movements of the clouds is to be welcomed, and we note, therefore, the little work of A. Ringwood, of Australia, in which he gives some methods, but by no means exhausts the subject. The methods that have been proposed and used are now so numerous and various that any one who will may easily make these important measurements. Among these is one proposed by the author in 1873, but not yet published: it consists essentially in throwing a beam of light vertically, or at any determined angle, by means of the reflectors used in public illuminations; an observation from a neighboring station of the spot of light on the under surface of the clouds gives their altitude; so that both by day and night the elevations may be determined. The formulæ, etc., for use in applying the photographic camera to this purpose during the daytime were communicated by the author in 1871.

Captain Miejahr gives in the *Hansa* a series of articles on clouds and winds of the coasts of China and Japan, which will be found to be eminently instructive.

The importance of systematic observations on the move-

ments of the clouds continues to be frequently urged. Clement Ley calls for as many co-operators as possible in this work, and Broun has carefully discussed his own most exact observations. Hildebrandsson has published, with numerous charts, a new edition of his studies into the movements of the upper currents of the atmosphere. None of these works, however, seem to be comparable in extent and importance with the magnificent series of maps that have now for seven years been published thrice a day by the Army Signal Office. These maps and the accompanying bulletins show the direction of the winds, the lower clouds, and the upper clouds; and as early as May, 1872, the author announced the law that the upper clouds moved towards a point to the right of the direction of the lower clouds, and subsequently that the lower clouds also moved to the right of the surface winds. He also stated that the prevalent mistaken idea that the upper currents were all from the west, or that a steady west current prevailed at great altitudes, arose from studying only cirrus clouds, which were, at least in the United States, generally found on the west sides of centres of high pressure (see *Bulletin Phil. Soc.*, Washington, 1871). The exact inclination of direction of lower cloud movement to the winds was first determined by Redfield in 1833–39, as about 7°. In the previous year Redfield had estimated at 45° or less the angle between the winds and the radius drawn to the storm-centre.

Buys-Ballot has published an extended discussion of the relation between the theory and observation relative to the connection between barometric pressure and the wind. To a certain extent this is an examination into the truth of the law known as Buys-Ballot's law, and published by him in 1857. This law has been so often modified by others as to have quite lost the simplicity of the wording of the author, who originally announced it thus: "When at two stations in Holland the deviations from normal pressures are unequal, the wind will, within twenty-four hours, be found to blow at right angles to, or within 30° on either side of, the line joining these." According to his present investigations, Buys-Ballot finds that the east and northeast winds set in less promptly than the west winds; and with regard to the gradients, he finds that these winds need a steeper

gradient than the south and west winds in order to acquire the same velocity. The law ordinarily called Buys-Ballot's was first demonstrated in 1853 by J. W. Coffin, and was expressed substantially as follows: The winds are inclined at an angle of 65° to the direction of the lowest pressure.

C. de Seul contributes to meteorology, as his *magister* dissertation, the results of most laborious toil, viz., the monthly, seasonal, and annual wind-roses for six stations in Southern Norway, and for the six climatic elements, viz., pressure, temperature, absolute and relative humidity, cloudiness, and wind-force. The scientific value of the work is highly spoken of by Mohn.

In Brault's "Circulation Amosphérique de l'Atlantique Nord"—a work of great labor, and apparently a worthy continuation of those studies that were begun by Maury, and to which Buys-Ballot, Buchan, Hoffmeyer, Brito de Capello, Cornelissen, and Scott have of late years made so many contributions—Brault has taken an important step in that he has undertaken to classify his 200,000 observations of the wind according to the force as well as according to the direction. Besides the excellent charts and the ninety pages giving in detail the data on which the charts are based, the author gives an interesting sketch of the actual state of the works in nautical meteorology that were begun in 1869 under the administration of Admiral De Genouilly, whence it appears that from the journals kept by French vessels the French Hydrographic Office has compiled a large number of charts and tables, which will, it is hoped, soon be published. A glowing tribute is paid by him to the importance of such simultaneous observations as the Signal Service is now receiving from all seas and lands. Brault's charts give not only the relative frequency of winds from each point of the compass, but also the probability of strong and light winds and calms, and furthermore the probable changes or order of succession of the successive winds; they are thus peculiarly adapted to the needs of the mariner, and are undoubtedly an improvement upon the charts that have hitherto been published at Washington, London, and Utrecht.

The position and phenomena of the equatorial calm-belt have been studied by Mühry with the help of the charts of the London Meteorological Office. He finds that the lowest

pressure agrees with the belt of highest temperature. The diurnal barometric period is well marked, and is, he thinks, evidently of telluric, not local origin. The trade-winds are, he thinks, evidently not the cause of the equatorial ocean currents, because the latter increase as the former diminish near the equator. The region of heaviest and most frequent rain is permanently about 5° north of the equator.

Two papers have been published in the Austrian meteorological journal by Guldberg and Mohn, in which the authors have rehearsed some of the views presented by them a year ago in their "Études." They deduce the angle of deviation of the winds from the line of steepest gradient as dependent on the geographical latitude and the coefficient of friction, and give in tabular form its value for different values of these fundamental quantities. Their method of determining the coefficient of friction and other resistances for each station is worthy of general application; in the cases computed by them for stations in England a very considerable difference is found for southwest and northeast winds. The observed wind velocities on sea agree closely with the theoretical, but those on land fall far below. The velocity at an altitude of 100 meters is but one per cent. greater than that at the surface of the ground, and for the determination of the coefficient of friction it is best to use only the relative directions of the wind and isobars.

Dr. Carl Benomi, in "Der Einfluss der Axendrehung der Erde" (Petermann, *Mittheil.*, 1877), gives a short reference to the history of this problem, and then takes a backward step in maintaining that east and west winds are not influenced by the earth's rotation. His essay is mostly confined to a consideration of the winds of aspiration and propulsion as defined by Mühry. Benoni commits the singular mistake of attributing to Dove that law which was known to Laplace, but was enunciated by Poisson, 1837; Foucault, 1851; Bénet, 1851; Babinet, 1854; Ferrel, 1854 and 1859; and by numerous authors since then, according to all whom, in our northern hemisphere, a body moving in any direction whatever deflects or tends to deflect to the right. This law is based on the principle of the conservation of areas, and differs essentially from the principle first enunciated by Hadley, and adopted by Taylor, Herschel, Dove, Colding, Maury, Peslin, Benomi,

and others, according to whom bodies moving on the parallels do not deviate to the east or west. This fundamental theorem in the dynamics of the atmosphere was abundantly elucidated in the discussion that was from 1851 to 1860 fully reported in the Paris *Comptes Rendus*. The more general law known as Poisson's in France, and in America as Ferrel's, was applied to the winds of the globe by Babinet, 1854, and simultaneously by Ferrel, whose complete memoir marks an important epoch in the development of meteorological science. A very complete review of the literature of this subject, so far as it relates to Baer's Law, is given by Benomi and Schmidt in the Vienna *Geog. Mitth.*

It is said that M. Finger, in a memoir on the mathematical theory of the motions of the atmosphere, has demonstrated among other things that the pressure is increased by easterly winds and diminished by westerly winds.

This latter scientist has enriched meteorology with a memoir, which is substantially a second edition of his famous paper of 1859, on the motions of the winds on the surface of the earth. This latter paper was too little known among European meteorologists until reviewed by Hann, a year ago, in the *Zeitschrift* of the Austrian Meteorological Society. The present writer, however, in 1865, and especially in 1869, had drawn the attention of certain individuals to this important memoir, and in 1871 quoted it quite freely in the pamphlet of "Suggestions on the Use of Weather Maps" (published by the Army Signal Office, 1st edition, May, 1871); while, in the meantime, Professor Everett, in his translation of Deschanel's Philosophy, had spoken of it in terms of highest praise. In fact, the fundamental problems of deductive meteorology were, for the first time, solved satisfactorily in this first edition. Professor Ferrel has simply revised his work in the light of the great mass of accurate data that have within twenty years been accumulated by the meteorological writers. The most important new features of the work consist in, (1) the formula for variation of pressure with altitude when the air is in motion; (2) the expression for the gradient of inclination of any current of water or air in a section at right angles to its course; (3) a table of mean temperatures over the whole earth, deduced by combining the best modern authorities; tables for January, July, and

the year are given, and the latter is condensed into a mean for each parallel of latitude, whence is deduced the following formula in centigrade degrees:

$$t=8.50°-1.75° \cos. \theta-20.95° \cos. 2\theta-1.00° \cos. 3\theta-2.66° \cos. 4\theta$$
(where θ is the the north polar distance);

whence, by integration, there results the mean temperature of the surface of the southern hemisphere, +16.05°; and of the northern, 15.30°; and for the whole earth, 15.67°, a result agreeing closely with Forbes and Von Waltershausen.

(4) In a similar manner new charts of isobars, based on the newest data collected by Rikatcheff, Hann, Buchan, etc., have been compiled by Ferrel, which, together with charts of the annual inequality, are all upon a polar projection.

(5) The general circulation of the atmosphere is deduced by reasoning based on the charts and the mechanical principles previously deduced.

PRESSURE AND ISOBARS.

The normal distribution of atmospheric pressure in Europe has been further elucidated in an important memoir by Buys-Ballot, published in the *Nederlands Jaarbooek.*

Buchan's paper on the diurnal barometric periods, in which he showed the decided influence of the relative distribution of land and water, has not yet been followed by the promised second part. And the conclusion formerly deduced by the present writer still seems to be inevitable—*i. e.*, that the diurnal and annual variations in the distribution of heat and moisture induce corresponding changes in the wind currents and consequently in the barometric pressure, the exact laws of which are contained in the formulæ of Ferrel's "Motions of the Winds on the Earth's Surface," though not developed by him with special reference to this interesting point.

This subject has been recently studied by Chambers, Broun, Belfour, Stewart, and Blanford. Starting with the idea of Kreil and Espy and others, that the expansion of the lower strata up to 10 A.M. is resisted by the weight of the surrounding atmosphere, thereby producing an increase in the pressure at the earth's surface, Blanford seeks to show that, at least in India, the greater part of the barometric irregularities result from the transfer of air from land to sea

and back again. In this explanation, however, Blanford makes no use of the important laws of dynamics, according to which the distribution of density (as depending on temperature and moisture and latitude) definitely fixes the law according to which the pressure must vary with the location and the time.

Professor Balfour Stewart, in some remarks on Mr. J. A. Broun's discoveries, maintains that the electrical state of the atmosphere may very plausibly be introduced to explain the general disturbances or tides in the barometric pressure.

Mr. Buchan has received from the Royal Society of Edinburgh the Macdougall-Brisbane gold medal for his paper on the diurnal oscillations of the barometer.

PRECIPITATION, CLOUDS, ETC.

The question as to the existence of fog vesicles is reviewed by Von Obermayer, who concludes that the assumption of fine drops of water suffices to explain all phenomena that have hitherto been ascribed to vesicles, and that the formation of fine drops is much more plausible on account of its simplicity. Angus Smith has observed in Iceland fog particles of $\frac{1}{300}$ inch diameter, or ten times that of the vesicles observed by Saussure.

Malloch has attempted to determine the altitude of the clouds by the comparison of photographic pictures taken simultaneously at two stations. This method, which was earnestly advocated by the author in 1871, seems calculated to give better results than any other, although demanding special precautions. Malloch estimates his extreme errors at three per cent. of the whole. He found the cirri of July and August to be at an altitude of from 22,000 to 27,000 feet; large cumuli (the bases) at 6000 or 7000 feet; rain-clouds appeared at all altitudes up to 4000 feet.

K. Antolik, of Hungary, calls attention to the remarkable phenomena shown when frictional electricity is allowed to act upon a quiescent cloud of tobacco smoke, which has flowed down upon and spread over a horizontal table. In this cloud he is able to reproduce the appearance of the most delicate cirro-cumuli, the cumuli, the mares'-tails, and other modifications of the forms of clouds. He would by these phenomena endeavor to explain the mode of forma-

tion of the ordinary clouds of the atmosphere; but however beautiful the analogy between the appearances may be, yet the physical explanations are not likely to be so similar.

In the annual reports for 1876 and 1877 of the Chief of Engineers, Mr. O. B. Wheeler gives a valuable reduction of all the observations of changes in level of the great lakes.

Dr. E. Purkyne contributes a very interesting paper on the rainfall at Santa Cruz. The author gives some account of the early condition of the forests, and of the droughts to which the island is subject. There is no evidence of any great change of climate or of the dependence of rainfall upon forests, but rather upon the presence of hills and the position of the water and land relative to the winds.

Dr. Hellmann has carefully studied the summer rainfall in Germany, using ten-day means for 22 years. He finds a double maximum in frequency and quantity — the first in June, the second in August. The cold period of June ends the first rain period, and is due to the irruption of cold air from the northwest.

Dr. Von Bebber (Munich, 1877) has collected a large quantity of data relative to the rainfall of Germany. He finds the average in all Germany to be 71 centimeters. The influence of altitude is to increase the rainfall upon such mountain-tops (up to 1200 meters) as were available. A similar distribution prevails in America on Mt. Washington, and in India on the windward side of the mountain-ranges, all which, by causing the winds to push the air upward, determine the resulting condensation.

Rubensen gives (*K. Svensk Vet.* p. 13, 1876) the geographical distribution of rain in Sweden. The rainfall is heaviest (700–800 mm.) in Southwest Sweden, and least on the east side of the Scandinavian Mountains.

As to the manner in which raindrops and hailstones are formed, Professor Osborne Reynolds maintains that there are in a cloud large and small particles of water and ice, and that of these the larger ones have demonstrably the greater velocity of fall; they will, therefore, overtake the smaller ones and add them to their own mass. These larger particles are most numerous at the upper surface of a cloud, where the cooling due to radiation takes place most rapidly. Beyond a certain limit raindrops cannot grow, as they will break up

as they rush through the air. The structure of hailstones, especially conical ones, shows that they have been formed by accretions on the lower side or base.

Professor Fritz, of Zurich, has published a characteristically thorough memoir on the geographical distribution of hail.

The classification of hailstones according to their external characteristics has been attempted in considerable detail by Prestel.

The formation of hailstones is considerably elucidated in a short article by Flögel, of Bramstadt, who, in some remarks upon a memoir by Reynolds, explains that the observations made by himself, and in 1791 by Wilke, and in 1844 by Schumacher, all point to the conclusion that a crystal of snow or ice, having once been formed at a considerable altitude, and descending rapidly, grows in size only by additions to its lower side; if, therefore, its original shape allows of it, it will keep the same end always uppermost, and will grow into a conical mass of ice, which will on its exterior be marked by ridges or striæ corresponding to the angles of the original crystal. In this connection we call attention to a fall of remarkably well-developed conical hailstones that is described in the *Weather Review* for April, of the Army Signal Service.

The hailstorm of April 4, 1877, is described by Godefroy in the *Comptes Rendus*, with numerous illustrations. Conical stones similar to those above described fell abundantly. The question as to whether hailstones are to be considered as built up from the sphere or the cone as the nucleus is settled by K. Fritsch, whose great experience entitles him to say that both are equally common.

The result of all the recent investigations into the diurnal change of temperature and moisture with altitude is thus summed up by Rubensen, of Upsala: The air at the earth's surface is, by the fall of its temperature, quickly brought to the point of saturation. From this instant on, a deposit of dew and a diminishing absolute humidity closely follows every lowering of the temperature. This diminution appears soon to reach a constant maximum, at which it probably remains for some time. Meanwhile, either through diffusion or by the descending current of air, new aqueous vapor is conduct-

ed from the upper strata of air downward to the earth. Therefore every stratum communicates to the next lower a certain quantity of vapor and receives a new share from above; but the new share is not fully equivalent to the loss, as is seen from the fact that an incessant diminution takes place in all the strata, although the precipitation occurs only at the earth's surface itself. The diminution of the humidity which corresponds to the difference between the quantity of moisture in the descending and ascending air strata begins subsequently in the upper air strata, which is a natural consequence of the fact that the diminution has its special cause at the surface of the earth. For the same reason it is also less the greater the altitude is, provided that the comparison between the different air strata is made at the same hour. Moreover, the diminution of humidity tends towards a limit or maximum value which, as the observations seem to show, is greatest at the earth's surface, where it occurs at the time of greatest diminution of temperature, and diminishes as we ascend.

STORMS.

Among the general treatises on meteorology lately published, we notice Scott's "Weather Charts and Storm Warnings," and especially Rosser's "Law of Storms," which latter is an impartial summary of the views of prominent meteorologists as to the rotation of winds about storm-centres.

Professor Loomis's seventh contribution to meteorology treats of rain areas, and shows that they have an elliptical form: they exist under the influence of (or within the limits of) areas of high pressure as well as of low; that rain is not a necessary attendant of an area of low pressure; that the depression at a storm-centre is, as first demonstrated by Ferrel, and now widely accepted, a result of the centrifugal force due to the wind. The heat liberated by condensation into rain does, however, exert a decided influence upon the development and progress of low areas. The eighth paper by the same author was read before the National Academy in October, but was not printed until after the 31st of December.

During a portion of December, 1876, and January, 1877, both Great Britain and the eastern portion of the United

States were visited by a succession of storms, in which high winds, heavy rains or snows, and very low barometric pressures were remarkably frequent. In the United States the tracks of the storm-centres, or areas of lowest pressure, as they moved eastward covered a region apparently far to the south of that which they ordinarily occupy, while their progress was generally very rapid. In Great Britain, on the other hand, the progress of storm-centres was unusually slow, frequently even stationary or retrograde, while the general path of the storm-centres was, as in America, far to the south of its usual position. In British America, on the other hand, and in Russia, low temperatures and high barometers were experienced. The minimum temperature recorded at St. Petersburg was on December 22, $-43.4°$ Fahr., being the lowest observed during the last 124 years. Farther eastward, namely, in Siberia, an unusual prevalence of warm weather was reported; and in the extreme west, on the Pacific coast of North America, unusually little rain and high temperatures prevailed. In fact, a general review of the movements of the atmosphere during these two months shows that there was an excess of cold dry air in northern latitudes and in the interiors of both continents, while over the Atlantic Ocean pressure was low and temperature and moisture were high. Both these conditions, therefore, caused a special development of the tendency to a cyclonic motion around the Atlantic basin.

These oceanic cyclones, as distinguished from smaller storms, are central over the North Atlantic and Pacific oceans and over the Antarctic continent, and must, according to the author's present knowledge of meteorology, vary in their intensity with any change in the solar radiation; the phenomena of the past winter harmonize entirely with the conclusion that during the present period of few sunspots the northern hemisphere has received slightly less heat than when the spots were large and numerous. A similar agreement between meteorological phenomena and this theory was noted by us about two years ago, but the satisfactory pursuit of these investigations can hardly be undertaken until we have a daily weather map of the whole world, or at least of the northern hemisphere.

Dr. Blasius, of Philadelphia, has contributed to the Vienna

Zeitschrift a review of the principal points of his work on "Storms, their Nature and Classification."

A welcome contribution to the theory of cyclones is given by Guldberg and Mohn in the third of their papers in the Vienna *Zeitschrift* elucidating the results given in their "Études." Assuming that descending and ascending currents of air exist, they develop the consequences, and give some of the laws controlling cyclonic and anticyclonic movements. In the interior of a cyclone the path of a particle of air is a logarithmic spiral with a deviation from the radius vector greater than that normal to the latitude and gradient. The formula connecting velocity and gradient as given by them agrees closely with observation.

The lamented J. Elliott, whose death occurred in February, 1877, had completed, shortly before his decease, a memoir on the Backergunde and Vizagapatam hurricanes of October, 1876, which is a model of thoroughness, and to be classed with the admirable monographs of Blanford and Wilson. Elliott inclines to the opinion that an extended region of calm bounded by opposing winds (trades and monsoons) preceded the initiation of these whirlwinds, and is the principal determining feature in all the Indian cyclones.

The report of 1877 of the London Meteorological Office states that a very large number of logs of vessels have been collected relative to the great hurricane of August, 1873, which passed near the coast of Nova Scotia. Daily weather charts and isobars for the whole month have been compiled for the North Atlantic Ocean, and the whole investigation, which will soon be published, is probably the most thorough that has yet been bestowed upon any Atlantic hurricane. It is said to be clearly shown that this hurricane did not reach Great Britain, as was suggested by the present writer in his brief preliminary report to the Chief Signal Officer in September, 1873.

A preliminary communication to the Royal Service Institution by Captain Toynbee, with its invaluable charts, shows that the hurricane was to a great extent broken up on the south coast of Newfoundland, and amounted to only a storm when it reached Norway.

Wijkander concludes with reference to the storms of the North Sea near Spitzbergen that they pass either on the west

side northward or on the south side eastward. The most of the centres of low pressure that follow the north coast of Norway turn east and southeast and pass on to the north of Nova Zembla into Russia. The other important storm-path is up the east coast of Greenland, west of Iceland, Jan Mayen, and Spitzbergen, then suddenly eastward to the north coast of Nova Zembla. The storms that pass up the west coast of Greenland are not felt at all on its east coast.

Mühry (Petermann's *Mittheilungen*, 1877, § 21), from the study of three westerly storms in Europe in 1873 (*i. e.*, January 23, March 11–13, December 16–19), concludes that these represented great equatorial currents penetrating from the Atlantic eastward deep into the interior of the cold region of Asia.

OPTICAL PHENOMENA.

The application of the spectroscope to the study of the atmosphere continues to be urged in a desultory way by Professor Smythe, who notes the occurrence of a severe rain on August 21, 1877, "marked by a heavy rain band in the prismatic spectrum of the daylight." The studies of Hennessey upon the atmospheric bands at the time of sunrise and sunset give, however, the proper clue as to the best method of making and utilizing this class of observations.

In discussing a large number of accurate observations of the scintillation of the stars, Montigny is led to the conclusion that the intensity of this phenomenon increases with the approach of rainy weather or moist weather at all seasons. The increase is noticeable one or two days before the rain arrives, and diminishes immediately after the rain ceases. When a barometric depression with strong winds passes near the observer, the scintillation is remarkably increased.

Lommel, after calling attention to the knowledge possessed by Biot, Brewster, Goethe, Arago, and Billet in reference to the polarization of the light of the rainbow, shows that the so-called Cartesian angle of incidence is that for which, for every substance and every color, according to Fresnel's theory, one ninth of the light polarized perpendicular to the plane of incidence will be reflected. For the whole rainbow the effectual rays are those that possess the maximum polarization. For a single prism the angle of minimum deviation corresponds to that of minimum polarization.

ELECTRICAL PHENOMENA.

Dr. Munk, of Marburg, quotes a sentence from the Talmud (*Tosefta*, Sabbath VII.) showing that in the fourth and fifth centuries before Christ the use of the lightning-rod was understood. Dr. Wiedemann adds that, according to Dumichen, the Egyptians gilded and coppered the highest projections, etc., "in order to protect from the celestial lightning."

The protection of buildings from lightning has been treated of recently by the eminent electrician J. C. Maxwell, who elucidates the idea, already defended in these pages, that a discharge cannot occur between two points within a building if the exterior is surrounded by a metal cage or sheathing, which latter need not be connected with the ground, but must, however, be joined to the gas or water pipes, in case any such enter into the building from without.

In a memoir upon the aurora of April 7, 1874, published in the report of the Chief Signal Officer for 1876, the author concludes that the auroral light emanated from a very low region in the earth's atmosphere, and spread east and west from certain well-marked localities.

An elaborate paper by Mann is reprinted with additions in the Papers on Professional Engineering.

RELATIONS WITH SUN-SPOTS.

The connection between solar-spot frequency and terrestrial phenomena has continued to receive some attention during the year, but not much progress has been made by the advocates of an intimate connection. Meldrum reports that the cyclones of 1876 in the Indian Ocean exhibited markedly diminished intensity, in accordance with his theory; Hunter, Hill, and Archibald have shown that the registers for different parts of India may be so construed as to lend plausibility to the idea that years of maximum and minimum rainfall follow the years of maximum and minimum sun-spot activity. The importance of the question in India is acknowledged in view of the disastrous famines that visit that land, and the British Government has been urged, through the London daily press, to institute a comprehensive system of hydraulic engineering, such that the surplus rains of one season may be husbanded for use in time of need. Such a sys-

tem was a thousand years ago in full operation, both in India and Ceylon, but has long since fallen into neglect.

Balfour Stewart has a very excellent paper in the proceedings of the London Royal Society, concluding that there is a slight balance of evidence in favor of a connection between atmospheric and solar phenomena.

Professor Langley, of Pittsburgh, as the result of a careful approximate calculation of the direct effect of sun-spots on terrestrial temperatures, shows that the least change in the mean annual temperature of the globe in the course of an eleven-year spot period is not less than one twentieth of a degree centigrade, and the greatest change is not greater than three tenths of a degree. In this estimate he only considers the direct effect of the diminished radiation of the spots, and can conclude nothing as to other, perhaps more important, changes, of which the spots are merely accompaniments.

RELATIONS WITH METEORS.

The meteors that encounter our atmosphere certainly communicate to its upper layers the heat due to the sudden stoppage of their motion, but of the exact amount of this heat we have but very indefinite ideas. A contribution to our knowledge of this subject has been made by Govi.

A remarkable meteor was visible from Kansas to New York on the evening of the 21st of December, 1876, and approximate determinations of its movements have been published by Kirkwood, Abbe, and Newton; the latter states that previous to encountering the earth's atmosphere it must have been coming from a point near to and a little south of the ecliptic, in the southern or eastern part of the constellation Capricornus; he solicits additional observations from those who saw this meteor, as he hopes to continue his study thereupon.

CLIMATOLOGY.

The climate of Chili is treated by Hann in an excellent *résumé* of the volumes of observations published by the Central Meteorological Office at Santiago, 1868 to 1872. The last volume is, he says, the most complete meteorological annual report that has as yet appeared from any part of America.

The climate of the Fiji Islands, as based on meteoro-

logical observations made during five years by R. S. Holmes, is the best account we as yet have seen of the climate of any of the South Pacific islands. The mean annual temperature is 79°, the highest 98°, and the lowest 58°; the number of rainy days 170 per year, and the annual rainfall 124 inches. The climate is a healthy one as compared with most tropical countries. Uniform northeast trades prevail.

Chambers, of Bombay, communicates to the Royal Society a memoir on the meteorology of that part of India, in which, after giving the results of twenty-seven years of observation, he discusses the relation of the facts thus presented to the present state of theoretical or deductive meteorology.

Dove has published his annual volume of monthly and five-day means for Prussian, Austrian, Swiss, and Italian stations.

Mr. C. Todd has published a work on the climate of South Australia, which is highly spoken of. He has at his disposal seventy rainfall stations, from which also weather reports are received. He finds that barometric changes progress eastward, occupying from two to four days in passing from Western Australia to Adelaide, and from twenty to forty hours in passing thence to Sydney and Brisbane, on the east coast.

The climate of Yarkhand forms the subject of the first of the Indian memoirs by Blanford, and introduces us to one of the most interesting spots on the globe. At an elevation of 4000 feet its temperature is that of Gibraltar and Messina in summer, but of Stockholm in winter. A high, thick haze of fine sand-dust replaces the clear skies of other parts of India.

Woeikoff gives in the Vienna *Zeitschrift* for November 1st, 1877, a sketch of the climate of inner Asia, based principally upon the recent explorations of Przewalski and Pylzof, who journeyed in Thibet, Mongolia, China, Gobi, and Alaschan.

Plantamour has published in one fine volume "Nouvelles Études sur le Climat de Genève," embracing a discussion of the observations since 1826.

The climate of Peking has been thoroughly worked up from twenty-three years' observations in a memoir by Fritsche. The temperature of Peking, as shown by observations in 1757–62, has not sensibly changed in 100 years.

The meteorological observations made at Abbasie, near Cairo, under the direction of Ismael Bey, have, we believe,

never as yet been published in full, but an interesting collation of such as have been made accessible to meteorologists has been compiled by Hann. The observations extend from 1868 to 1874, and are made eight times daily (at 0, 3, 6, 9 o'clock, etc.).

The diurnal and annual periods of the meteorological data for Cracow, as deduced from observations during 1867 to 1873, have been published by Dr. Karlinski.

The climate of Kerguelen Island, on the 49th parallel of southern latitude, has been approximately deduced by Hann from the collected results of observations made there by Ross in 1840, Cook in 1776, and the German Transit of Venus Expedition, 1874–75. On comparison with other points in the southern hemisphere, he finds this island to have an abnormally low mean annual temperature.

The climate of Switzerland is well presented by Billwiller in the means from twelve years of observations at the normal stations in that country.

The nations that have published their climatological data in accord, or nearly so, with the form recommended by the Vienna Congress, are as follows: Italy, 24 stations; Netherlands, 4 stations; Great Britain, 9 stations.

Wild has published, as a supplementary volume to his *Repertorium*, the first two sections of a great work on the distribution of temperature in the Russian Empire. These sections deal with the diurnal periodicity and the reduction of isolated observations to daily means. The subject is handled with great clearness and discretion, and will be a model for many future investigators.

HYPSOMETRY.

A year ago there was published a memoir by Grassi, of Milan, on "Barometric Hypsometry," in which he drew attention to the formula of Saint-Robert, published in the *Philosophical Magazine* for 1864, and in tabular form in the *Memoirs* of the Academy of Turin, Vol. XXV. This formula is based directly upon Glaisher's balloon observations, and, according to Grassi, gives most excellent results; but in a very interesting paper by Hartl it has been recently shown that the Saint-Robert formula gives altitudes decidedly too small throughout the year, at least for Mount St. Bernard,

and is no decided improvement upon those of Plantamour, Bauernfeind, and Ruhlmann.

As a perfect specimen of what a hand-book should be we recommend Dr. Paul Schreiber's "Handbuch der barometrischen Höhen-Messungen" (Weimar, 1877). The discussion of instruments and errors, formulæ and methods, leaves nothing more to be desired, as was to be expected from one who has had so much experience and is so high an authority.

AGRICULTURE AND FORESTRY.

The subject of forest-culture and the attending study of climate has of late years received increased attention. To the national bureaus of Switzerland and Bavaria we have now to add Prussia; this latter is under the direction of Dr. A. Muttrich, of the College of Forestry at Neustadt-Eberswalde; thirteen stations are occupied under him, and the annual reports for 1875 and 1876 have appeared during 1877.

Dr. F. B. Hough, formerly meteorologist to the State of New York, has about completed an extensive report to the United States Senate on Forestry; it is hoped that our government will give this subject special attention.

The influence of pine forests upon rainfall and atmospheric moisture has been investigated by Fautrat, who concludes that the pines have, even more than the leaf-bearing trees, the property of condensing the aqueous vapor; the atmosphere is also moister and the evaporation far less.

Fautrat has also studied the climatological influences of leafy and resinous woods. He finds that above the pines the maximum temperatures are higher and the minimum lower than outside of the forest, but in leafy forests the radiation of heat is counteracted by other phenomena producing heat. Within forests, especially of resinous woods, there is less ozone than in open ground.

A contribution to the relation between meteorology and agriculture is made by Professor Wolling, of the Agricultural Experimental School at Munich, in his "Investigation into the Temperature and Evaporation in Different Kinds of Soil."

CLIMATE AND HYGIENE.

The connection between climate and disease is treated of by Dr. J. Schreiber in a characteristically clear and interest-

ing address, in which he takes the advanced position to which all recent researches are unmistakably pointing, viz., that moisture and temperature and barometric pressure are for many diseases, such as consumption, yellow fever, etc., not the important factors to be considered by medical men in locating sanitariums, but that, on the contrary, these are but incidental to the more important question, "Is the air of the locality free from injurious organic dusts and germs?" He says, "The term 'climatic,' which we have thus far imagined to refer to some indefinite specific concerning which we could give no account, is become exceedingly clear and simple; it means, above all, air which is pure, containing no miasma, no organic or inorganic mixture, in which, therefore, rain or snow occurs" frequently enough to continually keep it washed and pure. If meteorologists would contribute to our knowledge of the sanitary relations of the atmosphere, they must also observe the organic dust floating therein according to the methods that are now well understood by microscopists.

The influence of high altitudes, or rather of diminished atmospheric pressure, upon health, and especially its curative influence in diseases of the lungs, has received an increasing amount of attention. Comprehensive memoirs upon this subject have been published by Denison, of Denver, Colorado, and Gleitsmann, of North Carolina. The volume by Dr. Bert on "Atmospheric Pressure and Animal Life" (Paris, 1876) seems to have turned attention strongly to this matter.

The general influence of climate on consumption was the subject of a Lettsomian lecture by C. T. Williams.

CLIMATE AND GEOLOGY.

The general relations between the condition of the surface of the earth and atmospheric conditions, especially the winds, is elaborately treated of by Czerny in "Die Wirkung des Windes," etc., in Petermann's *Geographische Mittheilungen* Ergänzungsheft 48. Most remarkable, however, is the view ably defended by Richthofen, that the immense "loess" deposit of China is the result of subaerial denudation.

From his experiments on the capillarity of soils, Klenze finds that with earths of the same degree of comminution the composition is of importance; thus quartz conducts faster than

kaolin. With different degrees of comminution, he finds the water rises higher in the soil in proportion as the particles of soil are finer: fineness is more important than chemical constitution. Up to a certain height the capillary elevation of water is slower as the soil is finer, but after that the ratio is reversed. The water rises more slowly in proportion to the number of non-capillary spaces, but it rises higher as the non-capillary spaces are fewer. The presence of salts in the water retards the capillary conduction in proportion to the concentration of the solution. For fine soils there seems no limit to the height to which water will eventually attain. The capillary action takes place downwards very nearly the same as upwards. The capacity of the soil when saturated by capillary action increases with the fineness of the particles nearly the same in loose as fine soil if only a few non-capillary spaces occur, but materially less when such spaces are numerous.

The influence of low pressure upon human life and health has been investigated by Mermod. His conclusions are: (1) The regular and prolonged sojourn at successively higher and higher elevations is accompanied by an acceleration of the pulse. (2) The regular and prolonged sojourn at 1100 meters above the level of the sea is not accompanied by any acceleration of the respiratory movements. From these two laws the following results can be drawn, and are confirmed by observation. (3) The mean fraction $\frac{1}{4}$, representing the ratio between the frequency of respiration and the beatings of the heart, always diminishes in proportion as one dwells at stations more elevated above the sea-level. (4) The temperature of the body does not sensibly diminish by transportation from residence at 142 to 1100 meters altitude. (5) Far from finding in the weight of the air breathed an increase in proportion as we dwell higher, there is rather a diminution. (6) The absolute and relative quantity of carbonic acid exhaled by the lungs increases by the removal to higher elevations, and that with an unchanged rate of respiration and a diminution of the weight of the respired air.

PHYSICS.

By GEORGE F. BARKER,

Professor of Physics in the University of Pennsylvania, Philadelphia.

GENERAL.

The activity in Physical Science during 1877 has been fully equal to that of any former year. The distinguished physicist, Professor Sir William Thomson, in his address as president of the Mathematical and Physical Section of the British Association at the meeting at Glasgow, September, 1876, after speaking in laudatory terms of Americans, American science, and the Centennial, discusses anew the question of the solidity of the earth, and gives the results of new calculations from precession and nutation to prove it, undertaken in consequence of suggestions made to him by Professor Newcomb, of Washington.

Main has claimed—and with justice too, apparently—with reference to the discussion in England concerning the meaning of the word "force," that it was used by Newton as the English equivalent of the Latin word *vis*, and not alone of *vis impressa*, as is maintained by Tait. When Newton wrote *vis insita*, *vis motrix*, *vis gravitatis*, *vis centrifuga*, he must have had in mind for each of these their ordinary English equivalents, in which *vis* always means force. This use of the word is by no means loose and inaccurate; it is rather general and comprehensive. Main closes by saying: "Some English mathematicians wish to have this valuable word all to themselves for a special technical sense; Newton claims no such monopoly, nor is it claimed at all by foreign mathematicians, nor conceded by metaphysicians; nor is the claim to this monopoly likely to be conceded until a better title to it has been shown."

Matthey has presented to the French Academy the bar of platinum-iridium made for the four-meter standard, to the order of the International Geodetic Association. To make it, 450 ounces of platinum and 55 of iridium were

melted by a jet of coal-gas and oxygen, and cast into an ingot. Five ingots thus made were cut into small fragments by hydraulic pressure, melted together and kept in fusion for a long time, and then poured into a single ingot. This was forged and rolled into bars, which were then fused in rectangular troughs. After forging, the metal appeared homogeneous, and gave a bar 35 centimeters long, 7.5 wide, and 2.5 thick, the density of which at 0° was 21.522. A third was cut off, and the other two thirds again forged into a bar 95 centimeters long, 2.5 centimeters wide, and 2 centimeters thick, having a density of 21.648. This was rolled between polished rolls nearly to the dimensions required, 4.1 meters long, 2.1 centimeters wide, and 5 millimeters thick, and then finished by passing it through a steel draw-plate. During all these rolling operations it was repeatedly annealed. In some remarks on this paper, H. Sainte-Claire Deville gave the results of his analysis of this alloy. He found 89.42 of platinum, 10.22 of iridium, 0.16 of rhodium, 0.10 of ruthenium, and 0.06 of iron. The density calculated from this composition is 21.51; that actually observed by him, 21.515. The third cut off of the bar above mentioned has been made by Deville into two tubes more than a meter long, closed at both ends, one of which has a capacity of more than a liter, designed for the determination of boiling-points. Both tubes carry marks exactly one meter apart. One of them communicates by means of a capillary tube with a Regnault manometer, and acts as an air thermometer; the pressure being determined by the manometer and the temperature by the elongation of the tube, compared with its fellow kept in ice, the expansion-coefficient being known.

MECHANICS.

1. Of Solids.

In Mechanics, Tschechowitsch has described a universal apparatus for illustrating the elementary laws of mechanics in class instruction. By its means the parallelogram of forces, resolution and composition of forces, the action of parallel and of oblique forces, action and reaction, the principles of the lever and of the balance, can be very fully de-

monstrated. It does not appear, however, to equal for elegance of construction or for universality of application the similar set of apparatus devised by the late Professor Willis, of Cambridge, and known by his name. This latter apparatus, by the way, deserves to be much more generally known in this country. As constructed by the Worcester Free Institute, it is invaluable in demonstrating mechanical principles.

Kimball has published an important paper on the variation of friction with velocity, in which, curiously enough, he harmonizes the statements of Morin and Coulomb, that the coefficient of friction does not vary with velocity, with that of Bochet, that it decreases as the velocity increases, and of Hirn, that it increases as the velocity increases, simply by showing that each is true at some given velocity. For very low velocities the coefficient is small; it increases at first rapidly, then slowly, until at a certain rate of speed it reaches a maximum; beyond this point increase of velocity decreases friction. The results of the above-named experimenters are explained by showing that Morin and Coulomb operated at velocities where the coefficient is near a maximum, and so obtained constant results; while Bochet operated at high and Hirn at low velocities. Kimball used in his measurements sliding friction down an inclined plane, sliding friction at uniform velocities on a horizontal plane, friction of belts on the surface of cast-iron pulleys, and friction of wrought-iron journals in boxes or bearings of different materials. The practical bearings of his results are highly important.

Sir William Thomson has described in *Nature* the results which he has obtained with his new astronomical clock, devised in 1869 with a view to improve both the compensation for changes of temperature and the form of escapement. The latter is a modified Graham's dead-beat escapement, the escapement-wheel consisting of only one tooth, being simply a piece of fine steel wire attached to a collar fitting loosely upon the shaft, and driven by friction from it, the shaft being connected with a suitable train of wheel-work with uniform motion, moving a trifle faster than the keeping of accurate time requires. To the lower portion of the pendulum-bob two pallets are attached, near the end of

the escapement-wire, so that at each semi-revolution of the shaft the wire, if too fast, will strike the pallet, and be retarded till the pendulum swings clear of it, the motion of the collar being thus governed by the pendulum. In the clock in the author's house, the arc of vibration does not exceed half a centimeter on each side of the vertical. As to the compensation, the zinc and platinum compensation at first adopted have been discarded, and mercury and glass substituted with the most satisfactory results.

Higgs has described a simple motor for preserving a pendulum in vibration during the course of an experiment. The pendulum is suspended through the coil of a Siemens galvanoscope, and automatically so breaks and closes the circuit that the deflection of the needle attached to the suspending rod upward or downward keeps up the motion.

2. Of Liquids.

Amagat has published in full his memoir on the compressibility of liquids, in which he especially considers the effect of temperature and of pressure upon the coefficient of compressibility. The apparatus consisted of a hollow iron rectangular base containing mercury, on the top of which was a pump to give the pressure (the piston being worked by a screw), a manometer closed at top and surrounded by a cylinder containing water, and a piezometer, the latter consisting of a bulb tube to contain the liquid to be examined, the open end being inverted and cemented into an opening in the iron base, and the bulb extending up into a chamber with glass sides, containing water at any desired temperature. The results, so far as the question of temperature is concerned, are in complete accord with theory, the coefficients increasing with the temperature. With regard to the influence of pressure, the author finds that within wide limits of pressure, and quite independently of the variation due to temperature, the coefficient always diminishes as the pressure increases. Thus for ether at 100°, the coefficient from 8 to 14 atmospheres was 0.000560, and at 30 to 36 atmospheres it was 0.000474, while at 13.7° it was 0.000168 and 0.000152 respectively.

Millar has made some experiments on the relative density of liquid and solid iron. He finds that pieces of pig-iron

placed in melted metal at first sink, but in a few seconds rise again and float on the surface. Flat bars of cast iron carefully laid on the surface continue to float. A solid ball $2\frac{3}{4}$ inches in diameter, lowered into the metal by a fine wire, disappeared completely at first, but rose in a few seconds and floated, with about half an inch diameter of surface exposed. Since in foundry practice $\frac{1}{96}$ is allowed for linear contraction of cast iron, the author believes that the finally cooled solid is denser than the molten metal; but as the sharpness of iron castings points to an expansion on solidification, he also believes that the contraction in cooling more than counterbalances the expansion during solidification. This view of the case is fully supported by the experiments on floating above described.

Sire has devised a new form of apparatus for demonstrating the hydrostatic paradox of Pascal. It consists as usual of three containing vessels, one cylindrical, the other two conical, the first with its base upward, the second with the base downward; but in the new apparatus the three are cemented at bottom into rings, giving their bases absolutely the same area. Below these rings are three glass cylinders communicating with each other, and filled with mercury. On filling the vessels with water, and opening communication between them to equalize the level in them all, the mercury in all the cylinders below is observed to stand at exactly the same height.

Hasler has proposed a new water meter, the peculiarity of which consists in the mode of counting. Upon the axis of the revolving drum is a steel bar magnet, which revolves close to the partition separating it from the counting wheels. Upon the axis of the lowest of these wheels is a second magnetized steel bar, smaller than the former. This is carried round by the larger bar solely through its magnetic attraction, and so effects the registration.

Trowbridge has made a series of ingenious experiments on vortex-rings in liquids, analogous to the smoke-rings of Thomson and Tait. Applying to this case the general equations of vortex motion, he draws the conclusion not only that all liquids falling upon the free surface of liquids from such a height that the surface of the liquid is not too much disturbed to enable the drop to be acted upon symmetric-

ally by the forces at the free surface will form rings, but also that a vortex movement can arise in the process of diffusion by a variation in density and pressure without the aid of initial angular velocities. The apparatus employed to produce the rings consists merely of a small glass tube, slightly smaller at one end, having a bit of cotton wedged in nearer the larger end, over which a piece of rubber tube is slipped. The apparatus being filled by means of the mouth with liquid, it can be ejected in such a way as to form the rings either at or beneath the surface of the liquid.

De Romilly has made some curious experiments on capillary action. He finds that if a bell-jar be covered at bottom with a cotton netting whose meshes are from one-eighth to one-twelfth inch in diameter, water drawn up into it will remain suspended, a well-pronounced meniscus being observable at each mesh. Moreover, although the strength of capillary attraction diminishes with the temperature, the water in the jar may be boiled by placing a Bunsen burner beneath the netting without falling through it. Special apparatus is needed to maintain the level, which the author figures and describes in his original paper.

De la Grye has studied the changes of form which are produced when two liquids of different densities are superposed and rotated with different velocities. If the more viscous of the two be uppermost, as in the case of oil and water, the oil becomes thinner in the centre, and if a more viscous liquid still, as a solution of gutta-percha in benzene, be used in place of oil, the appearances presented recall remarkably those of sun spots. If, however, the more viscous liquid be below, as, for example, oil and alcohol, the upper layer becomes thicker in the middle. It would hence appear that if the solar spots are formed by centrifugal force, the photospheric layer must have more cohesion than the gaseous substratum beneath it, and than the overlying chromosphere.

3. Of Gases.

Mendelejeff has made an extended investigation into the accuracy of Boyle's law of gaseous compression, special apparatus being used for the purpose, in which all possible causes of error were eliminated, and which allowed the most perfect accuracy of measurement. The experiments were

made at pressures varying from 700 to 2200 millimeters. The results obtained confirmed the conclusions of Regnault, although showing numerical differences in the values obtained, and proving, for instance, that the deviations of air from Boyle's law are even less than appeared before. But the most important result of the researches is that the divergences from Boyle's law, shown by the air being negative at pressures above the mean atmosphere, as was observed by Regnault, proved to be positive (volume decreases slower than pressure increases) at pressures below it. We must, then, conclude that the air experiences a change of compressibility at a certain pressure about the mean of that of the atmosphere; and this conclusion is supported by the circumstance that such a change has been also noticed in carbon dioxide and sulphurous oxide gases, but at pressures far lower than is the case for air. Only for hydrogen does the divergence continue positive for all pressures. Altogether we must conclude that the deviations from Boyle's law are far more complicated than has been suspected.

Romilly has communicated to the French Physical Society the results of his experiments on the use of a jet for aspirating and condensing gases. He finds, 1st, that the jet should be placed at a distance from the receiving tube equal to about four times the diameter of this latter tube; and 2d, that the conical opening of 6° given by Venturi for water is the best angle for air also. The first point is proved by finding that a gasometer is filled in two minutes forty seconds when the jet is placed in the interior of the receiving cone, in eight seconds when it is withdrawn a little from this cone, and in three seconds when it is removed four times the diameter of the cone. If a cone of 8° be substituted for the Venturi cone of 6° in the above experiment, sixteen seconds is required; and twenty-four seconds is necessary if only an opening in the thin walls of the vessel is used. Moreover, Romilly finds that the maximum effect is not obtained when the jet is central. The point of maximum effect varies with the distance between the jet and cone, the locus of these points constituting an ellipse.

Frankland has presented to the Royal Society a paper on the transport of solid and liquid particles in sewer gases—a subject of great hygienic importance in reference to the

zymotic and other germs whose presence is necessary to the development of epidemic diseases. In one experiment Frankland placed a solution of lithium chloride in a shallow basin, acidulated it with hydrochloric acid, and dropped in fragments of white marble. The effervescence carried off the lithium particles, and colored strongly the flame of a Bunsen burner held at the upper end of a paper tube five inches in diameter and five feet long, held vertically above the basin. A tin tube three inches wide and twelve feet long was placed above this, and the burner held over it, with the same result. The paper tube was then lengthened to nine and a half feet, and the amount of lithium present in the current seemed to be quite as great as before. The author concludes, 1st, that fresh sewage, through a properly constructed sewer, is not likely to be attended by the suspension of zymotic matters in the air of the sewer; 2d, that if the sewage be allowed to stagnate, the evolution of gas results, and the breaking of gas bubbles on the surface projects liquid particles into the air, and is a potent cause of the suspension of zymotic particles in the air of the sewer; and, 3d, that it is of the greatest importance that foul liquids should pass freely and quickly through sewers and drain-pipes.

Stoney has called attention to the erroneous conception ordinarily entertained of a vacuum. He assumes as probable that in a cubic millimeter of any gas at the ordinary temperature and pressure there is a "unit-eighteen" of molecules (1,000,000,000,000,000,000), and consequently asserts that in every cubic millimeter of the best vacuums of our air-pumps there remains a "unit-fifteen" of molecules (1,000,000,000,000,000). Even in the so-called Sprengel vacuum, as indicated by one-tenth of a millimeter of mercury on the gauge, there is a "unit-fourteen" of molecules (100,000,000,000,000), one hundred million million, in every cubic millimeter.

Wagner has modified his form of apparatus for determining the densities of gases by their times of effusion through minute openings in metal plates. In place of a straight cylinder, closed at top by the plate and open at bottom, which was plunged into a cylinder of water or mercury, he now uses a long U tube, closed at one extremity by the perfo-

rated plate, and below which is a three-way cock with a lateral tubulure, through which the gas is introduced. Two marks on the tube are the points between which the effusion time is noted, the gas being forced out through the plate by a water or mercury column in the open leg of the tube. The results obtained with the instrument were accurate for coal-gas and oxygen, but varied widely for hydrogen.

Kraevitsch has proposed an improvement in the construction of the barometer which increases indefinitely the sensibility of this instrument. To the shorter leg of a siphon barometer is attached a long horizontal capillary tube terminating in an open cylinder, the space above the mercury and the capillary tube being filled with water free of air. Obviously, if the barometer rises or falls, a quantity of water is displaced by the mercury equal to the volume representing the change in height. If now a bubble of air be introduced into the capillary tube, it will be displaced by an amount equal to the change in the barometric height, multiplied by the ratio of the two sections—in Kraevitsch's instrument by 140; thus rendering it extraordinarily delicate. The bubble when observed by a microscope of low power is rarely in repose.

An extended posthumous paper upon the constants of aneroid barometers and upon those aneroids which have scales attached for measuring heights, by Professor Jelinek, of Vienna, has appeared. It contains a complete *résumé* of previous results obtained by various observers.

ACOUSTICS.

Lord Rayleigh has experimented to ascertain the maximum limit of the amplitude of sound-waves, using for this purpose a whistle mounted on a Wolfe's bottle, furnished with a manometer. It was found that the most suitable pressure was 9½ centimeters of water, and that under these conditions the sound could be distinctly heard at 820 meters' distance. The amount of air passing through the whistle was found to be 196 cubic centimeters per second. From these data the required amplitude may be readily calculated. The result shows that the amplitude of vibration of the aerial particles was less than the ten-mill-

ionth of a centimeter. Indeed, the author is inclined to think that, on a still night, a sound of this pitch (f_{iv}), whose amplitude is only a hundred-millionth of a centimeter, would still be audible.

Mach has devised an apparatus for studying the sonorous waves produced by an explosion. The ball from a pistol perforates two disks of paper which close the ends of a long box, the walls of which are formed of glass smoked with lamp-black. The aerial waves produced by the two successive ruptures of the paper produce on the glass interference bands, by which the velocity of the ball may be calculated. The results are always lower than those given by the ballistic pendulum, and are brought into accord with these only by assigning 500 meters per second as the velocity of sound. It thus appears that the velocity with which sound travels increases with the suddenness of its production.

Mercadier has further studied the laws of the vibrations of tuning-forks, considering especially their isochronism with varying amplitudes. Three methods were used: in the first, the amplitude was maintained constant during each experiment, but was lessened from one experiment to another, the vibrations being recorded on a rotating cylinder; in the second, a large amplitude of vibration was given and then suffered to die out, the vibrations per second at various times being noted; in the third, a Lissajous curve was inspected as the amplitude of the fork lessened. The author concludes, 1st, that the duration of the vibration period of forks varies with the amplitude and in the same direction; 2d, that this variation, even for amplitudes as great as one centimeter, is small, affecting only the second decimal place; and, 3d, that if a certain limit, say four millimeters, be not surpassed, the duration of the period may be regarded as constant.

The same physicist has published a description of a new form of apparatus for showing optically the resultants of the combination of two rectangular vibrations, by means of which any desired difference of period and of phase can be obtained and maintained. The apparatus consists of a heavy fork vibrating by means of an electro-magnet, and having heavy sliders so as to vary the rate an entire oc-

tave. A small movable weight upon one leg, which can be adjusted while the fork is vibrating, and a mirror on the other, complete the apparatus. A second fork, without adjustment, but having a mirror and an electro-magnet, acts conjointly with the first one to produce the curves.

Decharme has investigated the pitch which bars of various metals and alloys of exactly the same size yield when vibrated transversely. The rods were twenty centimeters long and one centimeter in diameter, and they were supported at their nodal point, *i. e.*, four centimeters from the ends, upon prisms of cork, and struck with a wooden hammer covered with India-rubber. The pitch varied widely: lead gave only 690 single vibrations per second; while gold gave 970; silver, 1034.6; tin, 1161.3; zinc, 1422; copper, 1642.3; cast iron, 1843.6; wrought iron, 2192.2; steel, 2322.6; and aluminum, 2762. There is thus an interval of two octaves from lead to aluminum. From the data thus given the author calculates the coefficients of elasticity of these metals, which agree very well with those obtained by Wertheim.

Lootens has studied the phenomenon of air-motion in organ-pipes. By means of little pith propellers he has shown the existence in the pipe of cyclonic currents rising on one side of the pipe and falling on the other, the air producing them being that portion of the current which enters the pipe. If the pipe does not speak, this portion mixes with the other portion of the air by which the pipe is blown; but if it does speak, this cyclonic current does not mix with the other one, but takes a direction on issuing notably more inclined. These results being directly connected with the vibration of the walls of the pipe, the author concludes that this intermittent current, whose vibrations are determined by the walls of the pipe, acts the part of the perforated plate of a siren.

Ridout has described a simple burner for obtaining a very sensitive flame at feeble gas pressures. A tube five inches long and five-eighths inch wide is closed at one end by a perforated cork, through which slides a piece of tube one-eighth inch wide and six inches long, having the inner end drawn to a jet one-sixteenth inch wide. The inner tube is pushed up, the gas issuing from it lighted, and the tube slowly drawn down. A long steady flame is obtained which

is quite sensitive. By arranging two such jets, and connecting the gas-tubes with a horizontal tube in which is a drop of water, any difference of pressure is readily shown; lighting one jet causes motion towards the other side, as also does shortening the flame by noise.

Barrett has given in *Nature* a description of a flame extremely sensitive to entirely inaudible sounds. The flame came from an ordinary steatite burner, having an aperture of 0.04 inch in diameter, the gas being under a pressure of ten inches of water. This flame, which was two feet high, fell fully sixteen inches at every inaudible puff of a Galton whistle, and this even at the distance of fifty feet from the instrument.

A beautiful acoustic experiment by Tylor has been described in *Nature*, in which atmospheric vibrations are received on a soap film instead of a membrane. The end of a lamp-chimney is dipped into the ordinary bubble solution, and a film is formed over the opening. On singing near the open end, the series of forms belonging to the various notes become plainly visible in the film, and on reflecting the calcium light to a screen by the film, the figures come out on the screen with great beauty. If the solution be thin, the film is almost devoid of color; but if thick, a gorgeous scenic effect is produced by the masses of prismatic color whirled hither and thither by the musical vibrations.

Jeannel has observed that the radiometer is influenced by sound vibrations. In a dim light, when three radiometers were placed on the sounding-board of a parlor organ, all moved, two in the direction produced by light, the other in the opposite. He explains the result by the transmission of the vibrations mechanically to the vanes.

HEAT.

1. Thermometry.

Hervé Mangon has contrived a new registering thermometer of extreme sensibility and delicacy. A capillary tube containing mercury is bent to a narrow rectangle at one end, and is drawn out to a fine point at the other. This thermometer is inverted, and the point dips into a small dish of mercury on the scale-pan of a delicate balance. On the

other scale-pan is a vessel containing glycerin. This apparatus is placed at the point where the temperature is to be determined, the glycerin-cup being connected by a siphon and tube with the distant registering apparatus, and the beam being electrically connected with it. This apparatus is simply a differential wheel-work actuated by an electro-magnet, which causes a carriage carrying a pencil to traverse horizontally a prepared paper. Should the temperature rise, mercury would flow into the cup, cause the balance to descend on that side, make electric contact cause the wheel-work to move in one direction, carrying the pencil with it. At the same time the glycerin surface would be raised, and the liquid would flow through the tube into the reservoir, and lift a float. But the action of the clock-work at the same time depresses this float, raising the level of the liquid, causing it to flow back to the balance again, and thus to restore the equilibrium.

An Italian optician in Paris, says *Nature*, has constructed a very sensitive metallic thermometer on a new principle. The dilations of a small sheet of platinized silver are amplified by means of a system of levers, and the motion is communicated to a needle on a dial on which degrees are marked. The motion of the needle is almost instantaneous.

Fawcett has suggested a ready means of obviating the deposition of moisture which often takes place in the interior of minimum thermometers exposed on the grass. A piece of cork, about a quarter of an inch long, is cut so as to fit tightly around the neck of the thermometer tube, and then this tube with the cork packing is inserted into the glass case. The exposed end of the cork is covered with two or three coats of asphalt varnish, and when this is dry the protection is complete.

2. Expansion.

Reusch has described a simple form of apparatus for measuring coefficients of expansion as a lecture experiment or for students' use. Upon a horizontal axis, capable of rotation, a mirror is fixed at one end, while near the middle, but out of line with the axis of rotation, is an abutting screw, against which one end of the bar to be measured presses, the other end being supported by a similar screw in the base of the

apparatus. Any increase of length in the bar will rotate the axis and the mirror, and so may be observed and computed in the usual way. The bar to be measured is surrounded by a tank with glass sides, which may be filled with liquids at different temperatures. The price of the apparatus is only fifty marks.

Maskelyne has called attention to the similarity between the pitted surface of meteorites and that of the unburned fragments of coarse-grained gunpowder which fall at some distance from the muzzle of a large piece of ordnance. He expresses the opinion that the "pitting" is due to the sort of splintering effect of enormous heat suddenly applied, which results from the difference in the mechanical facility with which the sudden heat penetrates the mass at different points on its surface, melting out and dissipating in the air the material at those points, partly as a consequence of greater conductivity and partly of great fusibility.

Hartley has presented to the Royal Society a paper on the constant vibration of the minute bubbles which are found frequently in mineral cavities. In one case a cavity in quartz became two thirds filled with liquid at 3.5° C., the gas bubble occupying the remaining space, and having a trembling motion. As the cooling went on, the bubble decreased in size, and the motion became more and more rapid, until it finally moved across the cavity. He attributes the motion to the thermal changes which are taking place even within the crystal itself.

3. Change of State.

Gernez has studied the conditions under which the prismatic and the octahedral forms of sulphur are produced, and finds that when liquid and in the condition of surfusion at a temperature below 113° C., octahedral crystals are developed by a fragment of a crystal of this form, while prismatic crystals may be grown from the same surfused mass by contact of a piece of prismatic sulphur.

Beckerhinn has confirmed the conclusion long ago reached by practical experience by Mowbray, that congealed crystallized nitroglycerin is far less sensitive to shocks and blows than the liquid substance. He used in his experiments a fall-machine having a block of wrought iron of 2.13 kilograms

weight, at the lower end of which was a hardened steel point 7.068 square millimeters in area. A flat anvil of Bessemer steel was employed as a support for the nitroglycerin, which was placed on it in a thin layer, and the weight dropped on it from different heights. The mean height of fall necessary to cause explosion of the liquid was 0.78 meter, whereas the frozen nitroglycerin did not explode till a height of 2.13 meters was reached. The author has also determined some of the constants of the solid substance. The heat of fusion was found to be 33.54 units as a mean of three experiments. The density was found to be 1.735 at 10° C.—a temperature near its melting-point. The density of the liquid being 1.599, it follows that, in crystallizing, nitroglycerin contracts about $\frac{10}{121}$ of its original volume.

Wilson has proposed a simple mode of showing convection currents in liquids. A glass cell with flat sides has a brass tube in a depression in the bottom, which communicates with a steam supply. The tube is surrounded with a jelly containing aniline red, which is insoluble in cold water. On filling the cell with water, and blowing steam through the tube, the jelly dissolves, and colored currents stream up from below.

Guthrie has made a series of experiments to determine the effect of a crystalloid on a colloid when in the presence of water. Two or three lumps of rock-salt were added to a jelly of size, and the whole was hermetically sealed in a glass tube. The colloid parted with its water readily, a saturated solution of the salt was obtained, and the size became perfectly white and opaque, having undergone a structural change. Experiments were also made in which a more hygrometric salt, calcium chloride, was employed. The author thinks that it might be possible to fix the existence of a point at which the jelly does not give up its water to the hygrometric substance, and points out the analogy between a jelly and a mass of small bags filled with liquid.

The same author has also observed the curious fact that while a crystal of alum or a saturated solution of salt, when introduced into the Torricellian vacuum, depresses the mercurial column to a less extent than water, a solution of size, gum-arabic, or of any colloid depresses it to precisely the same extent. Hence water has different vapor densities in

its different states of combination, which the author is now engaged in measuring.

Hesehus has applied the electric current to the study of the spheroidal state of liquids. He finds (1) that this current is generally completely interrupted between the incandescent metal and the liquid spheroid, and that when it is not, this is due either to the fact that the liquid is in motion, and thus establishes momentary contacts, or that, the temperature of the metal being low, the drop is ready to burst; (2) that the interval separating the two—estimated by the galvanic deposition of copper—is about one tenth of a millimeter, though it increases with the temperature; and (3) that the temperature of the liquid, as measured by a thermopile, does not vary much from 96° to 97° C.

Bruhns has given a description of a new psychrometer and barometer devised by Bogen, of Chili. The former is a modification of Regnault's instrument, only instead of using the evaporation of ether to cool the bulb, the solution of ammonium nitrate in water is made use of. The peculiarity of the barometer consists in the method of filling, which is said to be very simple. It is the subject of a patent.

Garnett has described the method pursued in the Cavendish Laboratory, Cambridge, of exhibiting the phenomena of the passage of a gas through its critical point upon a screen in presence of a class. Dr. Andrews's apparatus was used, the image of the tube containing the carbon dioxide being projected on the screen with the calcium light, a microscopic objective enlarging it about 120 diameters.

Plank has determined the conducting power for heat of several gases. Calling that of air 1, that of nitrogen is 0.993; that of nitrogen dioxide, 0.951; that of ammonia, 0.917; and that of illuminating gas, 2.670.

Wiedemann has communicated an elaborate memoir on the specific heats of gases, one object of the research being to obtain as exact results as those of Regnault with less complicated and costly apparatus. Besides air, the gases examined were hydrogen, carbonic oxide, carbonic acid, ethylene, nitrous oxide, and ammonia. The specific heats correspond closely with Regnault's, though much more expeditiously obtained.

4. Radiation.

Crova has communicated a memoir on the measurement of the calorific intensity of solar radiations, and their absorption by the terrestrial atmosphere. The instruments used were an actinometer of his own construction and a pyrheliometer modified from that of Pouillet. He has observed an annual variation of the intensity of solar radiation analogous to the daily one, this intensity increasing rapidly from January to May, when it attains its maximum. He has observed no relation between the values of this intensity and those expressing the hygrometric state of the air.

Crova has subsequently described the actinometer which he used to measure the calorific intensity of the solar radiations and to determine their absorption by the terrestrial atmosphere. It consists essentially of a large alcohol thermometer, suitably incased, the bulb of which is exposed to the direct rays of the sun. Observations carried on daily and hourly enable the author to trace the curve representing the calories received by each square centimeter per minute. The differences observed in different hours of the day and days of the year enable the calorific intensity to be calculated as a function of the thickness of the atmosphere traversed, and to calculate an approximate value for the solar constant. Between 80 and 94 per cent. of the solar radiations traverse unit thickness of the atmosphere.

Haga has reopened the question of the absorbing power for radiant heat by aqueous vapor, and shows by his experiments that when columns of dry and moist air are allowed to ascend in front of a thermo-pile arranged differentially the effects are due to two causes: first, to the direct radiation of the air column, which has been cooled by passing it over moist pumice, or warmed by drying; and, second, to the evaporation from the face of the pile caused by the dry air which cools the pile, or to the condensation of moisture upon the face by the moist air which warms it. These two causes act in opposite directions; the second is the greater, and is temporary.

Aymonnet has made at the Sorbonne, under the direction of Desains, an examination of heat spectra, (1) to determine the distribution of the heat in the calorific spectrum pro-

duced by a Bourbouze lamp with a refracting system of flint-glass, (2) to study the variations of this spectrum with the temperature of the source, and (3) to observe also the absorption spectra of various bodies and their variations with the temperature of the source. Among other important facts observed, these experiments appear to prove finally a variation in the distribution of heat in the spectrum with the temperature, and also to show that flint-glass becomes less diathermanous as the temperature falls.

Aymonnet has also examined the specific absorbing power of bodies for radiant heat, using a thermo-pile and prism, the solution to be examined being placed between them. From his results he concludes that the atomic absorbing power appears to be constant, first, for all elementary bodies dissolved in the same menstruum, and, second, for all these bodies when existing in compounds of analogous chemical constitution.

The same author has studied calorific spectra by a modification of the ordinary method. He concludes that heat spectra contain easily recognized minima, that these minima are periodic, that they change their position when the source of heat is varied, that these variations are also produced by absorption, and that by these absorption changes much light is thrown upon the mechanism of solution.

The radiometer continues to be the subject of extensive experimentation. Among the papers which have appeared upon it, one of the most noteworthy, perhaps, is that of Mr. Crookes, in *Nature*, in which he says: "The results I have obtained seem to show conclusively that the true explanation of the action of the radiometer is given by Mr. Johnstone Stoney, according to which the repulsion is due to the internal movements of the molecules of the residual gas." He gives a number of highly interesting experiments with this instrument. Alvergniat seems to have made an *experimentum crucis* with the radiometer. By making the vanes of aluminum and silver, and by maintaining the globe during exhaustion at 400° C. in the vapor of sulphur, he obtained a vacuum so perfect that there was no rotation. On admitting a trace of air, however, rotation recommenced. Salet has modified the instrument in a very simple way in order to show the correctness of the molecular bombardment theory.

The vanes are fastened immovably to the glass support, and near them moves a disk of mica suspended from its centre. Exposed to light, the disk is caused to rotate rapidly by the molecules projected from the black surface.

Garbe has discussed the radiometer from the standpoint of theory, assuming that in this case the sum of the moments of different points relatively to a given axis is constant. From this three conclusions follow: 1st, the containing envelope being free to move, and the vanes starting from rest, when equilibrium is attained the rotations of the two will be in opposite directions with a velocity inversely as their moments of inertia; 2d, the vanes having a certain initial velocity, if the apparatus be left free, either (*a*) the globe will revolve in the opposite direction (in case the vanes revolve more rapidly), (*b*) it will remain stationary (in case the velocity of the vanes remains constant), or (*c*) it will revolve in the same direction (in case this velocity lessens); 3d, the apparatus being inverted and its parts thus becoming fixed, the action and reaction are equal, and no motion takes place under any conditions.

In a paper read to the Royal Society, Stoney has discussed the method by which heat is transferred across the vacuous spaces in Crookes's radiometers. He considered the laws under which this transfer of heat takes place, and showed that they are different from the already known laws of radiation, convection, conduction, and contact. Hence he suggests that this newly discovered mode of conveying heat should be called penetration. Numerous observations made more than thirty years ago by De la Provostaye and Desains, but not then understood, as well as more recent ones of Dulong and Petit, and of Grove, are readily interpreted by means of these newly discovered laws of heat.

Stoney and Moss have experimented to determine the relation of the force which moves the radiometer—and which they call "Crookes's force"—to the tension of the residual gas, and the influence of variations in the distance between the reacting surfaces. They find that with a residual tension of five millimeters there is a reaction through a space of at least ten millimeters; that at distances of twenty to eighty millimeters the force seemed to vary inversely as the tension; and that it appeared to be nearly independent of the dis-

tance when the tension exceeded twenty millimeters. They observed, moreover, sensible deviation from the law of inverse squares at most of the tensions.

Rood has described some very ingenious experiments on the radiometer, which show most conclusively that the theory which supposes the motion to be due to a reaction between the blackened surface of the vanes and the containing envelope is the true one. A two-vane mill with blackened surfaces of aluminum, and carrying a small magnet, was prepared, and before one of these surfaces was placed a screen of mica, also attached to the suspending wire. The whole was placed in a flask, which was exhausted to 0.25 millimeter. Light falling upon the unprotected vane alone, caused a deflection of 3.23°; upon the protected, 0.10°. When it fell on both there was a deflection of 2.38° in favor of the unprotected disk—thus proving that when reaction is prevented between the walls and the vanes no revolution takes place. The author also devised an experiment for measuring this repulsion. Experiments were also made showing that motion under atmospheric pressure is due to currents.

Volpicelli has also given the results of some radiometric experiments. He finds, for example, that a freezing mixture applied to the upper half of the globe causes a rotation with the non-blackened face foremost, as when radiant heat is used; but when applied to the lower half, the rotation takes place in the inverse direction, the blackened faces being in advance. In the latter case, radiant heat brings the mill to rest. The whole globe being plunged in a hot liquid or in a freezing mixture, there is no motion.

Crookes has given the name Otheoscope to a form of the radiometer in which, regarding the blackened surfaces of the vanes as the heater and the glass the cooler, and deducing from theoretical considerations that the latter rather than the former should be the moving body, a blackened fixed surface is so arranged that the stream of molecules driven from it shall impinge upon the transparent vanes and drive them round. In this instrument, unlike the radiometer, the glass envelope plays no part other than a preserver of the rarefaction. At the Royal Society's May soirée six otheoscopes of different forms and thirteen new radiometers were exhibited.

LIGHT.

1. Reflection.

Govi has proposed the use of thin layers of gold-leaf for obtaining good transmitting and reflecting surfaces in optical experiments. If upon the oblique face of a right-angled isosceles prism a very thin layer of gold be deposited by means of an alkaline solution of gold chloride and aldehyde, and then the prism be cemented by Canada balsam to a second and similar prism, a cube is obtained containing in its interior a surface of gold inclined at 45° to two opposite surfaces. By means of such a cube two images are seen—one by light transmitted through the film, which is of a pale green color; the other by light reflected from the film, and which is yellow. The cube thus becomes of excellent service as a camera lucida, etc. Govi proposes to place such a cube on the front of the telescope of a cathetometer, and then to compare directly the object to be measured with the equally distant scale by means of the direct image of the one and the reflected image of the other.

Wright has continued his researches on the volatilization of metals by the electric spark in vacuo, and has successfully applied the method to the production of mirrors. The glass to be metalized is placed in an exhausted globe, and a shower of sparks rained upon it from the negative electrode made of the metal to be used until the deposit was sufficiently thick. Platinum appears to be the best metal for specula, a perfect coat being deposited on a plate two centimeters in diameter in twenty to thirty minutes, the vacuum for the purpose being from 1.5 to 1.75 millimeters, and made on hydrogen. This layer was found to be 0.000174 millimeter thick, or one fourth of the length of a wave of red light. The author thinks this process may be brought into general use in the arts, the polish of the metallic surface being exquisite, far surpassing that obtained artificially.

Miller has described a new form of Wollaston's reflecting goniometer, which appears to him to have numerous advantages. There is nothing new in the leading principle involved in the instrument, the changes being mainly in the mechanical construction.

2. Refraction.

Mascart has made a research upon the refractive power of gases. A beam of light was sent through a collimator to two plates of plate-glass connected together at right angles; the halves of the beam were bent right and left by refraction through the glass, then passed parallel through two copper tubes containing the gases, and after refraction by a second system of glass plates placed in reverse directions, the halves were united again, and the beam passed through a slit to a system of prisms, then to a telescope. If the pressure in one of the copper tubes varied, the phases of the two parts of the beam became different, and from the number of fringes displaced the refraction of the gas could be determined. The influence of pressure was examined, then the refractive power for different wave-lengths, then the influence of temperature, and from these data the absolute refractive power was deduced. The figures obtained range from 0.1387 for hydrogen and 0.2706 for oxygen to 0.7036 for sulphurous oxide and 0.8216 for cyanogen. The refraction of a mixture is the sum of the refractions of its components; but that of a compound gas is in general greater than that of a mixture.

De Waha has proposed a new and simple mode of measuring the index of refraction of liquids. In a rectangular glass tank a piece of silvered glass is supported at any convenient angle to one side, this side being also silvered to one half its height. The tank being placed in the centre of a divided circle, a beam of light from a narrow slit is allowed to fall horizontally upon the side of the tank and normal to it, and then upon the piece of silvered glass, the circle being turned until this ray is also normal. The angle read off on the circle is the angle of the prism. The liquid to be examined is then poured into the tank, and the beam of light is so adjusted that its incidence in the liquid upon the silvered glass surface is normal. In this condition of things, the angle of refraction is the angle of the prism. Measuring then directly the angle of incidence, and dividing its sine by that of the angle of the prism, the refractive index is obtained.

Govi has suggested a mode of varying the focus of a microscope without touching the instrument or the object, and

without altering the direction of the line of vision. This is effected by interposing between the object and the objective a glass tank with plane parallel top and bottom, in which some liquid is placed. The height of the surface is varied by means of a suitable plunger.

Gariel has modified the ordinary projection instrument known as the phenakisticope, removing the disk which carries the figures, and doubling the number of lenses in order to give more light on the screen. Placing now a fixed object in the apparatus, as a round opening in a screen, for example, its image may be made to persist by sufficiently rapid rotation. Using two openings of different colors, their resultant may be shown. With a prism, the spectrum given when the apparatus is at rest becomes white when in motion. The apparatus shows the manometric flames very well.

Terquem has given the composition of a varnish which may be spread on glass without injuring its transparency, but which will enable it to take ordinary drawing-ink, so that various devices for the lantern may be drawn upon it. The varnish in question is composed of alcohol, 100 cubic centimeters; mastic, 7 grams; sandarac, 3 grams. It has been the practice for some years in this country to prepare plates for receiving India-ink by flowing them with a dilute solution of gelatin, one ounce to the pint of water. Very fine drawings can be made on it, and it is easily removed by water.

3. Dispersion.

Becquerel has examined carefully the ultra-red portions of the spectrum, using the principle of phosphorescence for the observation of this region.

Campbell has devised a double slit which he has used with good results for measuring the distances between the lines in the spectrum, and which he finds of great service in cases where the illumination is so slight as to prevent the use of the micrometer. One slit is above the other, the upper one being movable at right angles to its length by a micrometer screw of 200 threads to the inch, the graduated head of which is capable of indicating one five-millionth of an inch in the motion of the slit. If now a reading of the micrometer be taken when the slits are superposed and form

one continuous line, and a second reading when any given line has been superposed upon any other line at a moderate distance from it, the difference between these readings will enable us at once to ascertain the distance between the lines, if the micrometer be calibrated in terms of the spectrum as seen in the observing telescope.

Thalén has published the results of a joint investigation made by Angström and himself (but not published till after the former's death) upon the spectra of the metalloids, an excellent abstract of which by Schuster appears in *Nature*. They believe it extremely improbable that any lines present in a spectrum at a lower can disappear at a higher temperature. The electric spark and the actions it may cause are carefully studied, and applied to elucidate the carbon spectrum.

Boisbaudran has given, in a plate illustrating an extended paper on gallium, an excellent representation of the spectrum of this metal, together with all the other elemental lines which are found in the same vicinity.

Cleyden and Heycock have discovered the significant fact that the spectrum of indium, which is obtained by taking the electric spark between electrodes made of that metal, is quite different from that ordinarily given. Instead of three lines only, they found sixteen under the above circumstances. The lines usually figured are two in the indigo and one in the violet; they have wave-lengths, as given by Thalén, of 4532, 4509, and 4101 tenth-meters; the authors believe that the middle one should be 4510. The new lines have wave-lengths as follows: 6906, 6193, 6114, 6095, 5922, 5905, 5862, 5820, 5722, 5644, 5250, 4680, 4656, 4638, 4510, and 4101 tenth-meters. The first line is remarkable, since potassium, strontium, and antimony only give less refrangible lines.

Henry Draper has discovered the remarkable fact that oxygen exists in the sun, and that it and probably also the other metalloids show their presence in the sun-spectrum by bright instead of dark lines. By means of photography he has produced upon a single plate the solar spectrum from just above G to below H, and the spectrum of air ignited by a powerful spark between iron and aluminum terminals. Since the lines of iron in the latter spectrum coincide exactly with known iron lines in that of the sun, the non-shifting of

the plate is proved. The oxygen lines in the air spectrum, to the number of a dozen or more, coincide accurately with bright solar lines, every peculiarity in the shading or grouping of the one being reproduced in the other. The demonstration is complete, and will materially modify existing views as to the solar constitution. The discovery is the most important made in solar physics since that of Kirchhoff in 1860.

Young has made careful measurements of certain lines in the solar spectrum, observed alternately upon the eastern and western limbs of the sun, with a view to test the question of the effect of the motion of a luminous body upon the wave-length of the light which it emits. Using spectra of the sixth and eighth orders produced by a Rutherfurd grating of 8640 lines, the overlapping spectra being separated from each other by a glass prism of 45° placed between the grating and the object-glass, with its refracting edge perpendicular to the lines, the author succeeded in observing a difference in the position of the two D lines on the two edges, which, admitting Doppler's theory, would give a velocity of 1.42 miles per second for a point on the sun's surface. As direct observation gives but 1.25, Young inclines to the supposition that this difference proves that the solar atmosphere really sweeps forward over the underlying surface. Careful measurement of a line in the B group, which is due to atmospheric absorption, gave no displacement, as was to be expected.

Duboscq has contrived some simple and novel optical projection experiments. By means of a lens, the image of a small round hole is thrown on a screen; between the lens and the screen an Amici direct-vision prism is placed, capable of rotation about its axis. On rotating, the spectrum is circular—red within, violet without. Using polarized light and a double-image rotating prism, the extraordinary image describes around the ordinary as a centre a luminous ring, crossed by a black line parallel to the plane of polarization. The experiment may be varied by interposing a plate of quartz.

Egoroff has described a differential electro-actinometer devised in order to determine the coefficients of absorption of the ultra-violet rays by different bodies. For this pur-

pose he uses two Becquerel actinometers, one opposed to the other. The strength of the current produced appears to be in exact proportion to the intensity of the light.

Bezold has contrived a convenient method for comparing pigment colors with spectrum colors. It consists simply in replacing the scale of an ordinary spectroscope by a vertical slit a millimeter wide, before which the color to be studied is placed. The eye sees then the spectrum color by refraction and the pigment color by reflection, and by a movement of either slit the two colors may be brought into exact coincidence.

Holmgren, at the request of the direction of the Swedish railway between Upsala and Gefle, has examined the entire staff of officials with reference to color-blindness. Out of the 266 persons examined, no fewer than eighteen were found who could not distinguish color, and were therefore utterly useless and unfit for railway service. An investigation of this sort on some of the leading American railways would undoubtedly be of service.

Thompson has submitted to the test of experiment the common impression that objects appear brighter when seen with two eyes than with one, using an ingenious apparatus by which two beams of light (one polarized, the other unpolarized) give to two Nicol prisms, one in front of each eye, the same quantity of light. It appears from these experiments that light is more powerful in producing an effect when concentrated upon one eye than when equally distributed to the two; but the light so concentrated on one eye does not produce the sensation of twice as much illumination as the half of the light viewed by both eyes at once.

Rood has called attention to and confirmed an observation made by Tait which bears on Young's subjective color theory. Tait observed that on awaking from a feverish sleep a lamp flame assumed a red color, lasting for a second. Rood first noticed the same result twenty years ago, in Munich, on recovering from anæsthesia by chloroform, when the face of the operator appeared ruddy and his hair purplish red. He now has observed a chronic condition of the same sort, lasting for a couple of weeks, during convalescence from typhoid fever. White objects appeared orange yellow. On Young's theory this result is explained by supposing that the nerve

fibrils of the retina, which are sensitive to red, resume their functions soonest. Hence the author infers that the apparatus in the eye for the reception of waves of medium length is more liable to be overstrained than that designed for waves of greater or lesser length.

Kühne has made some new and remarkable experiments in optography. Following out the suggestion of Boll, that the retina of an animal kept in the dark for a long time is purplish red, the color being bleached by daylight, he has succeeded in fixing upon the retina the image of objects seen by the animal before death. To repeat the experiment, the animal, after being kept for a long time in the dark, is decapitated, and each of the eyes exposed in turn to a bright object — as, for example, the skylight of the laboratory. The retinæ are removed from the eye in presence of sodium light, and placed in a five-per-cent. solution of alum. After becoming hard, they may be separated from the optic nerve and inverted. Upon a beautiful rose-colored field a brilliant and sharply defined image of the skylight appears, showing even the sashes. In one of Kühne's experiments a second image appeared, to his surprise, but it was due to the second skylight with which the laboratory was lighted.

Carey Lea has studied the sensitiveness to light of various salts of silver. Premising that these salts are sensitive, 1st, by being darkened, 2d, by receiving a latent image rendered visible by a deposit of metallic silver, or, 3d, by receiving an image which is made visible by decomposition by alkalies in connection with reducing agents, he gives the results of his experiments to ascertain the sensitiveness of various salts in the third way above mentioned. Silver platinocyanide gave the strongest image, though none of the substances tried at all approached the haloid silver salts in sensitiveness. Moreover, he observed that no substance insensitive in the absence of tannin became sensitive by its presence.

4. Interference and Polarization.

Trannin has devised a new method of photometric measurement for lights of different colors, with which he has examined and compared the luminous intensity of different portions of the spectrum. The method consists in superposing the spectra of the lights to be compared, and then producing

in these spectra interference bands, which disappear in any given part of the field common to the two spectra when the intensities are equal. The instrument is an ordinary spectroscope, the two spectra being obtained, the one above the other, by the common device of a reflection prism. Between, now, the collimator and the prism the author places a Foucault prism to polarize the beam horizontally, a plate of quartz cut parallel to the axis to produce a considerable difference of path between the ordinary and extraordinary rays, and a Wollaston prism to bring back the light rays into two planes at right angles to each other, and at the same time to double the images of each half of the slit. Four channelled spectra are now visible in the instrument, two of these (one polarized vertically, the other horizontally) overlapping. Consequently the brilliant maxima of the one coincide with the dark maxima of the other; and when the intensities are equal, the bands completely disappear. The method is simple and satisfactory.

Rücker has given, in *Nature*, an account of some interesting experiments with black soap films, *i. e.*, films of soap and water so thin that no light is reflected by them, and they appear black. He has observed that, under whatever conditions the black film may have been formed, a remarkable and very rapid change of thickness invariably occurs at the boundary which divides the black from the colored portion of the film. By an exceedingly happy method, the thickness of the film was measured by measuring the resistance of a known area. The value of the resistance of a black ring one millimeter broad was 1,750,000 ohms, from which the calculated thickness is twelve millionths of a millimeter, or one forty-ninth part of the wave-length of D. Various measurements prove this thickness to be approximately uniform.

Thompson has communicated to the London Physical Society, says *Nature*, a paper on interference fringes within the Nicol prism. If the "field" of a Nicol be explored by the eye, it will be seen to be bordered on one side by a margin of violet-blue light, and on the other, when the light passes obliquely through the prism, by an orange band, within which lie a series of colored fringes; these latter are very clearly seen with monochromatic light, when a second set within the blue band also appears. The author showed that

these two sets are due to interference taking place within the film of balsam at the critical angle of total reflection for ordinary and extraordinary rays respectively; they are, therefore, analogous to the interference bands in a thin film placed beneath a prism of a more highly refracting substance, and occurring just within the limit of total internal reflection, as first observed by Sir W. Herschel.

Stone has exhibited to the London Physical Society some diffraction gratings on glass and metal, ruled by W. Clark, of Windsor Terrace. The majority of them were close spirals, about 1000 to the inch, which gave brilliant circular spectra, the slight difference between spirals and true circles not being apparent. The metal gratings were linear, 1000 to the inch, the spectra being much more brilliant than the refracted ones. The German silver and cast steel hitherto employed not being suitable, the author proposes the use of speculum metal. The idea is not new, Saxton having ruled lines for this purpose for Bache many years ago. The exquisite speculum-metal gratings of Rutherford are well known. He much prefers them to glass silvered, and his latest triumphs in this direction abundantly justify the preference.

André has studied theoretically the phenomena of diffraction in optical instruments and their influence on astronomical observations.

Bezold has suggested another and a very convenient method for studying the laws of color-mixture. A prism of Iceland spar is placed in the interior of a blackened tube, which is closed below by a disk having four squares cut out of it. The prism, of course, gives, on looking through it, double images of the squares, and in a certain position two of the eight are brought to coincide with two others in the middle. Surfaces of different colors being brought under the two squares occupying, say, the upper row, their composite color is obtained in the middle image. It is then easy to find what color must be put under the lower two squares to obtain a color in the middle corresponding to the one above.

Baily has examined microscopically the optical properties of starch grains. He concludes that they are transparent bodies, consisting of an interior nucleus surrounded by coats, and explains their appearance in polarized light by supposing the starch to be doubly refracting, with two axes of elas-

ticity at each point in the plane of the disk, one of which is directed towards the centre of this disk.

Soret and Sarasin have investigated the rotatory power of quartz, extending their observations to the ultra-violet rays as far as the line R, using in general the method of Foucault and Fizeau, modified by that of Mascart. The numbers obtained agree well with those calculated by Boltzmann's formula.

Henri Becquerel has submitted a large number of substances to the influence of magnetism, and examined them with polarized light, to determine whether the magnetic rotatory polarization of these bodies sustained any relation to their other physical properties. He finds that this magnetic rotation in general increases with the refractive index of the body, nearly as $n^2 (n^2-1)$, and draws a number of important facts from this conclusion.

ELECTRICITY.

1. Magnetism.

Wild has examined the properties of a nickel-magnet made by Joseph Wharton, of Philadelphia, and given by him to Kotschubey, of the Russian commission. The magnet was 155 millimeters long, 9.5 wide, and 2 thick, the ends being pointed. It weighed 25 grams. Its magnetic moment, determined in the usual way, was, per gram, 112,000 as received, and 186,000 after remagnetizing; while that of a nearly similar steel magnet was 245,000 and 368,000 respectively. On analysis by Butlerow, the only impurity was iron, of which there was present one third of one per cent.; traces of cobalt were also detected. Wild concludes, 1st, pure nickel, unlike iron, takes considerable permanent magnetism, but the amount is only from one half to one third of that taken by different sorts of hardened steel; 2d, the magnetism remaining in nickel is less permanent than in hardened steel; 3d, the temperature-coefficient is less in the case of nickel than in that of hardened steel; and, 4th, the temporary magnetism acquirable by nickel, though about twice its permanent magnetism, is only half that which hardened steel and only one fourth of that which soft iron is capable of acquiring.

Du Moncel has studied the relation which should exist between the diameter of iron cores and the thickness of their magnetizing helix, and finds from experiment that there is an advantage in winding electro-magnets so that the thickness of the coil-layers is equal to the diameter of the cores. Moreover, the diameter of the cores should naturally be proportioned to the electric intensity which is to act on them, and be so chosen that they shall be nearly saturated by the current.

Helmholtz has communicated to the Academy of Berlin a paper containing the results of experiments by Rowland, which satisfactorily prove that electric convection currents are dynamically equivalent to the flow of electricity in a conductor, and are electro-magnetically operative.

2. Electromotors.

Zöllner has investigated a new class of electrical phenomena hitherto but imperfectly known. When two different bodies, an insulator and a half-conducting rubbing instrument, are rubbed together, electrical currents occur in the rubber as follows: if the rubbed insulator be positively electric, the currents at the surface of contact or in the interior of the rubber are parallel, but opposite to the relative motion of the insulator; if the latter be negative, the currents of the rubber are parallel and in the same direction as the insulator's motion. These currents were measured, and shown to be often very considerable. They could be intensified by multiplying the rubbers and connecting their corresponding parts with wires. They lessen the useful effect of an electrical machine, in which, however, a positive advantage is had by uniting the electricity of the positive end of the rubber with the positive electricity of the conductor. The author has also studied a variety of related experiments, as, for example, the currents generated by the flow of water through a thin tube. Zöllner concludes that diaphragm currents and their modifications are due to the occurrence of new electro-motive forces, such that the electric current they generate in the moved liquid, so long as it is in contact with the canals of the diaphragm or the capillary tube, are always opposite to an electric current which would force the liquid in the same direction through the diaphragm

which is caused by the mechanical pressure which is operative.

Fuller has communicated to the Physical Society of London a description of a new form of electrical machine, called an electric multiplier, which is essentially a double-acting electrophorus. It consists of a vulcanite quadrant, over which electricity is distributed by a metallic arm, carrying needles which swing over it, the charge being removed from the other side by a similar set of points attached to an arm connected to earth. Two quadrantal metal plates being now automatically brought in contact with the vulcanite, receive a strong charge, which becomes free on removing again the plates from the vulcanite.

Hagenbach has made some experiments in the university of Basle to ascertain the effective performance of one of the smaller Gramme magneto-electric machines used as a source of light for lecture-room purposes. He finds as follows:

Rotations per Minute.	Cubic Centims. of Gas per Minute.	Electro-motive Force in Bunsen Cells.	Candles.
1700	119	40.8	628
1800	126	43.2	689
1900	133	45.6	506
2000	140	48.0	567

The work done at 1800 revolutions was 90 kilogrammeters, or about 475 candles to the horse-power. The machine was driven by a water motor, and the light cost nearly seventy cents per hour. As to give the same light from a battery would require from seventy-two to eighty Bunsen cells, the light from the machine is much the cheapest.

Anthony has also given some measurements of the performance of a Gramme machine constructed in the workshop of the Cornell University. According to the results given, the machine, when making but about 500 rotations, gave a light of 1600 candles; but as, unfortunately, the horse-power consumed is not stated, no opinion of the efficiency of the machine can be formed. Further experiments are promised.

3. Velocity.

A paper has been published by Wand on the propagation of electricity in cylindrical conductors, which is an extended mathematical discussion of the whole subject. He finds (1)

that the character of the propagation of electric disturbances of equilibrium is different according as the resistances to be overcome are small or great; (2) that with small resistances—such as that of 120 to 400 kilometers of copper wire 2 millimeters in diameter—restoration of the equilibrium takes place by oscillations, the amplitude of which diminishes the more rapidly the greater the resistance; (3) that with great resistances—such as 1000 kilometers of the above wire—no oscillations are observed, the velocity being inversely proportional to the total resistance and to the length of the conductor, and hence, for two conductors of equal specific resistance, being inversely as the square of the length; and (4) that the velocity of electric signals magnetically produced is not, except in cases where the resistance is very large, comparable with that of disturbances of electrical equilibrium, the latter being the greater. One curious result the author draws from his investigation, *i. e.*, that when the resistance in the circuit is very small, the motion of the electricity takes place almost exclusively upon the outer surface of the conductor.

W. Siemens has experimented to determine the velocity of electric propagation. The two outer armatures of a condenser were connected together; the two inner ones, one to the line, the other to a short wire. Both terminated in points close to a revolving smoked cylinder. On putting the arc connecting the outer armatures to earth, the condenser is discharged, and two sparks pass to the cylinder, the difference between them indicating the time of traversing the line. Siemens concludes that electricity has an actual velocity of propagation.

Sabine has proposed to use the time taken by a condenser to discharge itself, or to pass from one potential to another, through a circuit of known resistance, as a unit for measuring very small intervals of time.

Edison has discovered the fact that the conductivity of graphite loosely compressed is remarkably increased by pressure, probably from improved internal or external contact. He has utilized this discovery in the construction of his talking-telephone by placing such a cylinder of graphite against the brass or mica diaphragm which receives the sound and in the main circuit. The electrical current, which

is inversely as the resistance, copies faithfully the varying pressure of the sound-waves, and transmits them along the line.

4. Electrolysis.

Ayrton and Perry have published an account of an elaborate series of experiments on ice as an electrolyte. As a result of their experiments, they state that the capacity per cubic centimeter of ice at —13.5° C. is 0.002 micro-farad, and the specific inductive capacity is 22,160 (that of air being called unity), while that of water at 8.7° is about 2240 times this amount. Commencing with ice at —13.6° C., the temperature was allowed to rise, and the conductivity determined by galvanometer readings. From these a very regular curve was deduced, which shows that the conductivity increases regularly, and that there is no sudden rise in passing from the solid to the liquid state. The same apparatus was also used to determine the electro-motive force of polarization-currents at different temperatures.

Helmholtz has published a note containing the results of a research made at his suggestion by Root to ascertain whether in galvanic polarization the electrolytic gases remained on the exterior or actually penetrated the platinum. The experiments show a very rapid penetration of the platinum, so that if for only five minutes the platinum plate experimented on and one to the right of it were connected with a Daniell's cell, a condition of polarization was developed between it and a plate to the left.

Bertrand has experimented on the electrolytic preparation of the metals, and has prepared aluminum, magnesium, cadmium, bismuth, antimony, and palladium from their aqueous solutions in this way. The current employed should be strong, and the concentration of the solution carefully regulated.

5. Electric Spark.

Spottiswoode has described the new enormous induction coil made for him by Apps, which is capable of giving sparks 42 inches long. It has two primary coils—one used for long sparks, the wire being 660 yards long and 0.096 inch diameter; the other, for fat sparks, has 84 pounds of wire, instead of 67. The secondary wire is 280 miles long, and forms 341,850 turns. In the two central sections the diameter of

this wire is 0.0095 inch, and in the two outer ones 0.0115 and 0.0110 inch. The condenser consists of 126 sheets of tin-foil 18 by 8.5 inches, separated by two thicknesses of varnished paper 0.0055 inch thick. Glass 3 inches thick has been pierced with the 28-inch spark of this coil, using five cells of Grove.

Spottiswoode also has experimented to determine the conditions of stratification in exhausted tubes, and finds that in a tube, one terminal of which is connected with the negative coating of a Leyden battery, while the other is held beyond striking distance from the positive coating, the discharge will show the separation of the positive from the negative part by a dark intervening space, and under suitable conditions of exhaustion will also show striæ. Decreasing the distance from the positive coating produced a stratified discharge. He concludes that by a suitable disposition of a Leyden battery the phenomena produced by it coincide with those produced by the induction coil.

Thompson has repeated and varied the experiments of Edison on induced sparks, from which the latter concluded upon the existence of an "etheric" force. He has obtained these sparks ten millimeters long, and shows that they are made up of alternating currents of very short duration.

Lommel has figured two interesting electric dust figures analogous to those of Lichtenberg, but in which the rod conveying the discharge lay horizontally on the vulcanite plate instead of being vertical. One of these is positive, the other negative, and they were produced by dusting a mixture of red-lead and lycopodium powder on the plate after several sparks had passed into the rod.

Wright has studied the production of transparent metallic films by the electric discharge in exhausted tubes, and has obtained some curious results. The colors obtained by transmitted light were, for gold, brilliant green, thinning out to pinkish violet; for silver, pure deep blue; copper, dull green; bismuth, grayish blue; platinum, gray; palladium, smoky brown; lead, olive brown; zinc and cadmium, grayish blue, inclining to purple; aluminum, brownish; iron, neutral tint; nickel and cobalt, gray or brownish gray; tellurium, purple; magnetite, gray brown. The light transmitted is powerfully polarized, the polarization increasing with the incident

angle. The metals of high atomic weight volatilize most readily.

Barat proposes to use, for the Franklin portrait experiment, in place of a gold leaf, a gilded plate of glass, having two strips of tin-foil across the ends and the portrait outline, paper and press as usual. One spark is sufficient; a second uniformly breaks the apparatus.

Gripon has published two interesting experiments in static electricity. In the first, two equal strips of copper are placed at the top of a metallic stem, the lower one fixed, the other moving on a pivot. If the apparatus be placed in the neighborhood of an electric machine, or even of a charged sphere, the two strips arrange themselves perpendicularly to one another. If the upper strip be replaced by a magnetic needle, a deflection more or less decided is also observed. In the second, a capsule completely full of oil of turpentine is placed beneath a permanently electrified sphere. The liquid is attracted, and a column of it rises to the ball, in which very complex movements may be observed, the whole recalling closely a water-spout.

Berthelot having proved that even under the ordinary electric tension of the atmosphere a silent discharge may be caused in a tube containing nitrogen, by means of which this gas may be absorbed by organic bodies to form new compounds, proposes this result as one which must necessarily go on in nature. Hence he insists upon the necessity of studying consecutively and methodically the electric condition of the atmosphere, since upon its tension this absorption of nitrogen depends.

Maxwell has communicated to the Physical Section of the British Association a paper on the protection of buildings from injury by lightning. Premising that the precautions ordinarily taken in the construction of lightning-rods are calculated rather for the benefit of the surrounding country and for the relief of clouds laboring under an accumulation of electricity than for the protection of the building on which they are erected, he goes on to advocate the protecting of a powder-mill, for instance, by sheathing its roof, walls, and ground-floor with thick sheet copper, since, under these circumstances, no electrical effect could possibly occur within it by reason of any thunder-storm outside. Ordinarily, how-

ever, it would be quite sufficient to carry a No. 4 copper wire round the foundation of the house, up each of the corners and gables and along the ridges. If there are no metallic connections with distant points, such as water and gas pipes, it is not necessary to take any pains to facilitate the escape of the electricity into the earth.

Baxendell subsequently called attention to the fact that the above system of protecting buildings from lightning was suggested by the late Mr. Sturgeon in a paper read before the London Electrical Society on March 7, 1838. Mr. Sturgeon, moreover, advocated an efficient earth connection—a measure absolutely essential to prevent damage should the building be struck by lightning.

Fitzgerald has communicated to the Royal Society the important fact that a ray of plane polarized light, when reflected from the polished pole of an electro-magnet, is not simply rotated, as Kerr supposed, but emerges elliptically polarized. To account for this result, he supposes differences of density of iron in different directions due to the magnetization; whence two circular rays of unequal indices, which by their combination produce, of course, an elliptic ray.

Gordon has repeated with care the experiments of Kerr on the effect of electric charge in causing double refraction in glass, and has been entirely unable to produce the results, though the means employed were as powerful and as delicate as the latter's.

Lodge presented to the Glasgow meeting of the British Association an ingenious mechanical apparatus for illustrating many electric phenomena, such as the passage of electricity through metals, electrolytes, and dielectrics. In the apparatus the current is represented by an inelastic endless cord, the electro-motive force by a weight tending to urge the cord forward. Resistance is shown by buttons moving on the cord with friction, attached by strings more or less elastic to the supports, by means of which counter-electromotive force is represented.

6. Electric Light.

Gauduin and Gramme have experimented to determine the effect of the introduction of various more or less difficultly fusible substances into the carbons employed for the

electric light in increasing the brightness of the arc. The substances used were bone-ash, calcium chloride, borate and silicate, silica, magnesia, magnesium borate and phosphate, alumina, and aluminum silicate. The proportions were so regulated that, when burned, the carbons should contain about five per cent. of the foreign substance. The results show that only with the bone-ash was the light increased measurably, but that the fumes produced are serious objections to the use even of this.

Reynier has suggested a new form of electric lamp, the carbons in which have the form of disks, in contact, or nearly so, at their peripheries, and rotated by clock-work. To one of them an automatic arrangement is attached, which electro-magnetically controls the distance between the electrodes, and that instantaneously. This device, the author believes, will enable him to divide the current, and so to maintain several electric lights at the same time by a single machine.

Chikolef has made a series of experiments at St. Petersburg to determine the lighting power of the electric light at great distances. The power of the light is notably increased by covering the carbon of the lamp with a thin sheet of copper (one sixteenth of the diameter of the carbon at its upper part, and from one forty-eighth to one sixty-fourth in its lower part). It depends also upon the direction given to the carbon, the best being to turn the cup towards the object to be lighted. The great machine of Alteneck, with a carbon twelve millimeters in diameter, gave a maximum light equal to 10,210 candles, and a mean light of 5739 candles; while with a carbon of ten millimeters, but galvanically coated, it gave a maximum of 16,255 candles (20,275 when the cup is turned as above), and a mean of 14,039 candles. The light was sufficient to make objects visible (for military purposes) at a distance of 3080 yards. Of many machines used, the most economical proved to be the great Alteneck.

Jablochkoff has devised a new form of electric lamp, very simple in its construction, having absolutely none of the mechanical arrangements ordinarily used. It consists of two carbons permanently fastened parallel to each other, and at a small distance apart, separated by some insulating sub-

stance capable of disappearing in some way as the carbons burn, the substance used by the discoverer being either kaolin or a mixture of sand and powdered glass. To prevent the more rapid consumption of the positive carbon, it is made of proportionately greater cross section, the author having found that the relative rapidity of consumption depends on the strength of the current. The light is double that given by a regulator, and with an ordinary Gramme machine current four lights were produced at the same time.

Experiments have been made in both London and Paris with the electric candle of Jablochkoff, using two carbon strips placed side by side, insulated from each other by some non-conducting substance which melts or volatilizes as the carbons burn. At the West India Docks in London four of these candles were simultaneously burned with the current from one magneto-electric machine. The large yard was brilliantly illuminated, although the candles were enclosed in ground-glass shades; so that it was possible to read small print at a considerable distance, while at the same time the eyes were not affected by the glare, as is the case with the ordinary electric light. The second trial was the lighting of the top story of one of the large warehouses, and the third the lighting-up of a large vessel at the quay, both of which were successful. Each candle gave a light equal to that from 100 gas-lights, and at a very much less cost.

Another form of Jablochkoff's light has been variously tried, which seems likely to be of more practical use than the candle. It consists of a thin kaolin plate, only four millimeters thick, but eight centimeters long and two or three wide, having the conducting wires fastened in grooves at the ends. These wires are coarse, and come from the secondary coil of an inductorium, the primary coil being in the circuit of an Alliance magneto-electric machine, driven by a three-horse engine. When the secondary current crosses the kaolin plate it apparently ignites, giving a soft mellow light equal to that from eight gas-burners. In the Paris experiments three electric candles, each equal to five kaolin lights, were operated in the main circuit, while ten of the kaolin lights were operated by as many secondary circuits, thus making it possible to feed twenty-five lights at once in

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different places by the same machine. These experiments were made with a view to utilize these lights at the Paris Exhibition.

Tyndall, in connection with Douglass, has made a report to Trinity House on the comparative value of various magneto-electric machines for light-house purposes, an abstract of which appears in *Nature* for October 25th. The machines compared were those of Holmes, Gramme, and Siemens. The performance of the small Siemens machine particularly impressed them. Its power, in relation to its size, is surprising. The large machine of Siemens, however, greatly transcends both his small machine and the single machine of Gramme; it is sensibly equal to the two Gramme's machines coupled together, the price of the former being less than half that of the latter. The light from the large Siemens, as also that from the two coupled Grammes, is of extraordinary splendor. Combining either the large machine of Siemens, the two Gramme's machines, or, if practicable, the two small machines of Siemens, with one of the group-flashing dioptric apparatuses which have been recently devised by Dr. Hopkinson, a light transcending all other lights now existing would probably be obtained.

7. Thermo-Electricity.

Streintz has described a new form of Noë's thermo battery, and has given the results of some measurements with it. The positive metal consists of an alloy of 62.5 antimony and 36.5 zinc, and the negative metal of German-silver wire. The battery contained four series of 27 elements each, so arranged as to be combined in two series or in one only. The electro-motive force estimated by Fechner's method was that of 4.3 Daniell cells; the resistance, 2.7 Siemens units.

Naccari and Bellati have investigated the thermo-electric properties of potassium and of sodium at various temperatures, using pairs formed by one of these metals and copper in the earlier experiments, and lead in the later. The results show that the passage of a unit of electricity from a cold section to another warmer by one degree, transports, following the direction of propagation of the negative fluid, a quantity of heat equivalent respectively to 2529 units of work for the potassium and 4129 units for the sodium. The neutral points are at $-62.04°$ and $-212.4°$.

CHEMISTRY.

By GEORGE F. BARKER,

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GENERAL.

Among the interesting *Chemical* papers of the year we note one by Berthelot on certain chemical phenomena produced by the electricity of tension. In these experiments a Holtz machine was employed, one electrode of which was connected by means of a platinum wire with the internal coating of a sealed tube containing the substance to be acted on, the external coating being connected with the internal one of the next tube, and so on, the second electrode of the machine being put in communication with the last outer coating. No spark can possibly occur within the tubes, though they are incessantly charged and discharged, but always with the same kind of electricity. He finds that ozone is formed from oxygen equally well by positive or negative charges, though the amount produced is increased with the tension, being five or six per cent. for sparks one centimeter long, while with sparks of half a millimeter only one or two thousandths is formed. No production of nitrous compounds was observed with a mixture of nitrogen and oxygen. Acetylene was formed in quantity when organic vapors were placed in the tubes. Nitrogen was freely absorbed by organic bodies such as paper and dextrin. Experiments are in progress to determine the cause of the special action thus exerted.

Terreil has published an extended paper on Dulong and Petit's law of atomic heats, in which he compares together the products of specific heat and atomic weight of bodies in the state of vapor, and finds a close accordance with the law. He asserts that a body not gaseous has a specific heat twice that which the same substance possesses in the gaseous condition.

Victor Meyer has described an improved form of appara-

tus for showing the increase of weight in combustion where the products are gaseous. Upon each scale pan of a balance is placed a candle. Above it is a glass gas chimney, having gauze at bottom, and containing several large pieces of caustic soda, suspended to the stirrup. One of the candles being lighted, in a very few minutes that side of the balance preponderates. In six minutes there is a difference of weight of a gram, and in fifteen minutes of more than three grams.

A lecture was delivered in March before the London Chemical Society, by T. E. Thorpe, on the theory of the Bunsen lamp, in which he gives first a bit of history relative to its origin, and then discusses the results of Mallard as to the velocity of inflammation in meters per second of various mixtures of coal-gas and air, of Blochmann on the composition of the gas at various parts of the flame, and of Heumann and Frankland on the cause of the disappearance of luminosity in the flame.

Müller has proposed a simple apparatus for determining approximately the density of gases, as a lecture experiment. A well-closed half-liter flask, through the cork of which passes a glass tube drawn out to a point, is taken, and water is boiled in it until all the air is expelled from its interior, when the point is sealed. After cooling it is carefully weighed. The difference is the weight of the contained air, corrections being made for the tension of aqueous vapor and for temperature. Replacing the stopper by a second having two tubes, and again expelling the air from the flask, it is successively filled from a gasometer with the gases to be weighed, and their weights determined in succession. The method is quite accurate.

NON-METALLIC.

Schobig, at Kämmerer's suggestion, has experimented to determine the effectiveness of a solution of potassium permanganate for the purification of hydrogen gas for analytical uses. He finds it highly satisfactory, the impurities present—sulphur, arsenic, antimony, phosphorus, and carbon—all being completely removed. The hydrogen itself is oxidized by the solution, but only to a slight extent. The hydrogen thus purified the author finds will reduce silver.

Corne has observed that if to an aqueous solution of an iodate there be added a few drops of water in which phos-

phorus has been kept, iodine is liberated. The reaction is due to the phosphorous acid present. To detect an iodide, this is first oxidized by boiling with a few drops of sodium hypochlorite. The addition of the phosphorus water sets free iodine at once, which is recognized by starch or carbon disulphide.

Berthelot has studied the thermic conditions attending the formation of ozone. He finds that in the production of one molecule of ozone from oxygen there is an absorption of 29.6 calories. Being therefore a body formed with the absorption of heat, its activity chemically is accounted for: it is a magazine of energy stored up under the influence of electricity.

Cohne has observed that if a sprig of any fresh plant be placed in a weak solution of hydrogen peroxide, oxygen is disengaged which is strongly ozonized. If flowers are upon the sprig, they also evolve oxygen, but less actively. A convenient method of setting free a little ozone in the air of an apartment is to place a bouquet of flowers in weak hydrogen peroxide in place of ordinary water.

Kämmerer has called attention to the occurrence of gelatin in all forms of water coming from the soil, and has suggested that water intended for consumption should always be tested by means of tannin for this substance. If no precipitate or turbidity appears after standing twenty-four hours, the absence of an appreciable quantity of gelatin is assured. Any turbidity, however, proves the water impure.

Frankland has published a paper on water-analysis, in which he examines the value of the albuminoid-ammonia process, and concludes that it is "entirely useless in the examination of waters for sanitary purposes." He claims, however, for the combustion process, that it is the only one which gives trustworthy information concerning the organic matter present, the only one which can determine the carbon, and the only one which shows the ratio of nitrogen and carbon.

Fairley has studied the action of various bodies on hydrogen dioxide, with a view to determine the cause of the decomposing action they exert. In the case of the metals—silver, for example—he believes that there is first an oxidation, and then a reduction again, due to the reaction of the silver oxide upon the hydrogen dioxide.

Cooke has described a method for manipulating hydrogen sulphide which possesses many advantages. In general, the apparatus used is that commonly employed for generating and dispensing carbonic-acid water, some minor modifications being made in it.

Berthelot has examined experimentally the assertion of Schönbein that, in presence of alkalies, the nitrogen of the air is oxidized to nitrous compounds by ozone. Both oxidation of phosphorus and the silent electric spark were used to produce the ozone. But while he confirmed Schönbein's statement that nitrous compounds are formed in presence of oxidizing phosphorus, the author could not obtain evidence of the oxidation of the nitrogen by the ozone.

Berthelot has also called attention to the absorption of free nitrogen at the ordinary temperature by various organic bodies, notably benzene, oil of turpentine, marsh gas, acetylene, and even cellulose, under the influence of the silent electric discharge.

Storer has examined elaborately Schönbein's test for nitrates, which consists in applying the iodo-starch test after reducing to nitrites by means of zinc. In his opinion, the fatal defect of the test is the production, even by the action of zinc on pure water, of hydrogen peroxide, which colors the iodo-starch. He finds that this may be entirely obviated by acidulating the water before reducing. One tenth of a milligram of nitric acid in 50 cubic centimeters of water containing two drops of dilute sulphuric acid gave the reaction distinctly.

A new and apparently satisfactory process has been proposed by Etard for the preparation of alkali nitrites as reagents, which consists in reducing the corresponding nitrate by a sulphite. Equivalent quantities, for example, of potassium nitrate and potassium sulphite, previously well dried, are mixed together and fused in a crucible. After cooling, the mass is taken from the crucible, pulverized, and treated with alcohol, in which the nitrite only is soluble. Or the separation may be effected by crystallization.

Hampe has made a somewhat exhaustive investigation of the so-called boron obtained by different methods, and concludes that no pure boron in crystals has ever yet been seen. He finds that the black monoclinic prisms produced when

carbon is absent consist of about 17.30 per cent. of aluminum and 82.70 of boron, corresponding to the formula AlB_{12}. The yellow crystals, quadratic in form, which have been supposed to be an allotropic form of boron, the author finds to contain 13.15 per cent. of aluminum, 3.76 of carbon, and 82.81 of boron, from which he derives the formula $C_2Al_3B_{48}$ for the substance.

Wright has continued his studies upon the gases contained in meteorites, and now gives the results of his examination of the Kold Bokkeveld meteorite, which, though stony, contains considerable carbon and some bituminous matters. It yielded 25.23 volumes of gas, of which 93.11 per cent. was carbon dioxide, the remainder being carbon monoxide, marsh gas, hydrogen, and nitrogen, the two latter in minute quantity. It also yielded ten per cent. of water, in which chlorine and sulphurous oxide were detected. The manner of occurrence of the gases within the meteorite is also discussed.

A note has appeared by Böttinger giving the results of his experiments with carbonous oxide and hydrogen cyanide, in a research upon glyoxylic acid. He finds that when pure carbonous oxide is conducted over pure dry hydrogen cyanide, well cooled, it is actively absorbed. If the solution be mixed with a concentrated solution of hydrogen chloride and agitated, no evolution of gas takes place, even on agitation, the liquid separating, on standing, into two layers. If, however, the vessel be removed from the freezing mixture, a rapid stream of pure carbonous oxide is evolved. Pure hydrogen cyanide is left, showing that the CO was simply dissolved. He hence calls attention to the remarkable solubility of carbonous oxide in hydrocyanic acid.

Hartley has made further examinations of the liquids contained in mineral cavities. He finds that the liquid carbon dioxide present varies considerably—from 27.27° to 33.7° C. —in its critical point in different mineral specimens, often varying in different cavities in the same mineral specimen. The presence of this substance in sapphire and topaz leads him to the supposition that these minerals may have been formed by the action of aluminum fluoride or chloride upon calcium carbonate at high pressures, producing alumina and carbon dioxide. Where water is also present in the cavity it would seem that the reaction had taken place in presence

of moisture. As to the diamond, the author thinks that this mineral is the result of the action of reducing agents upon very highly compressed carbon dioxide at temperatures above its critical point—a condition of things which suggests a new direction for speculation and experiment.

Zöller has recommended the vapor of carbon disulphide as an antiseptic agent. Prepared from potassium xanthate, its odor is but trifling. Experiments show that five grams of this liquid volatilized in a space of about one seventh of a cubic meter will preserve twenty kilograms of meat placed in this space for from two to three weeks.

METALLIC.

Jean has proposed a method of titrition for the sulphates of the alkalies, which is as follows: The aqueous solution of the sulphate is treated first with baryta water in excess, then with carbonic-acid water decanted from the mixed precipitate of barium sulphate and carbonate, the liquid boiled, the whole filtered, the precipitate washed out, the filtrate and washings concentrated and titered as usual with a standard sulphuric acid. From the quantity of free alkali carbonate present, the quantity of sulphate originally united to it is known, being the exact quantity employed in neutralizing the alkaline filtrate.

Johnson has prepared potassium tri-iodide, by evaporating over sulphuric acid a saturated solution of iodine in potassium iodide. At first dark-colored cubical crystals of the iodide, colored by iodine, were deposited; but in a few days lustrous dark-blue prismatic crystals, sometimes two inches long, separated, which had the composition of the tri-iodide, and were extremely deliquescent. Their specific gravity was 3.498.

Frey has given the details of the manufacture of the alkali-earth metals in Görlitz which were exhibited in London and Philadelphia. In general the electrolytic method of Bunsen is closely followed, the current being weaker. From two and a half to four grams were produced at each operation. Calcium is not yellow, but resembles aluminum closely, being brittle like it, and not being malleable or tenacious. Strontium is bright brass-yellow, very malleable, easily rolled and drawn, and oxidizes much easier than cal-

cium. Barium cannot be obtained as a globule, its fusing-point apparently being above that of cast iron. From amalgams of this metal, by distilling off the mercury, masses of over 100 grams were obtained, sintered together. Lithium was obtained in two-gram globules. Cerium has the precise properties given by Wöhler, burning with explosive violence.

Mallet has described an aluminum nitride obtained by acting upon sodium carbonate by metallic aluminum at high temperatures. The remaining metallic regulus showed projecting crystalline points, which were separated by solution in hydrochloric acid and examined. They were apparently short rhombic prisms, with dihedral summits of a bright honey yellow color and translucent. They were brittle and not hard enough to scratch glass. On exposure to the air for a week or two, ammonia is evolved and alumina is left. Fused with caustic alkali, ammonia is given off and an alkali aluminate formed. Analysis showed 67.9 to 68.27 per cent. of aluminum and 31.73 to 32.1 per cent. of nitrogen, corresponding very well with the formula Al_2N_2, which requires 66.18 per cent. of aluminum and 33.82 per cent. of nitrogen.

Gladstone and Tribe have continued their researches on the simultaneous action of iodine and of aluminum upon ether and compound ethers. With ether the experiment was made by taking twenty cubic centimeters and adding to it twenty-seven grams of iodine and two grams of finely cut aluminum foil. The temperature rose at once, and the ether began soon to boil violently, being prevented from escaping only by an inverted condenser. Ethyl iodide and aluminum iodo-ethylate were the only products. The compound ethers used were the acetates of ethyl and amyl, and the results of the reaction were aluminum acetate and iodide of the alcohol radical. The authors use these reactions to explain the action of aluminum and iodine upon water.

Heumann has succeeded in producing an ultramarine containing silver in place of sodium by heating the blue ultramarine with a concentrated solution of silver nitrate in sealed tubes to 120° Fahr. for several hours. The product, washed with boiling water, and separated by agitation from the metallic silver, appeared under a magnifier as a perfectly uni-

form powder, consisting of lemon-yellow clear grains, without crystalline form. Analysis showed them to contain forty-eight per cent. of silver.

Boisbaudran, in a paper on the physical properties of his new metal, gallium, states that it fuses at about $+29.5°$, and therefore liquefies readily when held in the hand. It maintains the liquid condition with great persistence, a fragment having remained liquid for the month of February, capable of being united and separated, like mercury. When solid it is remarkably hard, resembling aluminum. It crystallizes readily, does not oxidize at a red heat, and is not volatile. Its density is 4.7, approximately.

Boisbaudran subsequently presented to the French Academy a specimen of gallium crystallized in the form of octahedrons truncated at the base. They appear to be clinorhombic.

Cresti has described a very delicate test for copper. Two small wires, one of zinc the other of platinum, connected at one end, are placed in the solution suspected to contain this metal. A black deposit appears on the platinum wire. To test this, it is washed and placed while still moist in a mixture of hydrogen-bromide gas and bromine vapor (such as is obtained by acting on potassium bromide by strong sulphuric acid). The deposit, if copper, becomes a deep violet liquid, especially distinct when placed on a white plate, which the author believes to be a solution of cuprous bromide in hydrogen bromide. Copper may thus be detected in a few cubic centimeters of a one-millionth solution.

Thudichum and Hake have made a series of experiments on metallic copper and its power of occluding hydrogen, with a view to test the question of its influence upon the accuracy of those organic analyses in which it is used. From the results obtained they conclude (1) that copper-wire gauze which has never been used, when oxidized and subsequently reduced in a current of hydrogen, being allowed to cool in the gas, occludes a very appreciable amount of it, being about 0.6 milligram per 100 grams of copper; and (2) that the gauze loses this property after several repetitions of the process. The error introduced into analysis is therefore trivial.

Eccles, working in Thorpe's laboratory, has found that the

copper-zinc couple of Gladstone and Tribe reduces potassium chlorate readily, but is entirely without action on the perchlorate. By means of this reaction he has studied the character of the decomposition of the chlorate by heat, and proves that no perchlorate is formed when manganese dioxide is used.

Shaw and Carnelley have examined the question of the protecting action of copper sulphide upon metallic copper. Two pieces of this metal were taken, exactly alike, one of them immersed in dilute ammonium sulphide till coated with copper sulphide, and then both placed in water, with and without access of air, and in various saline solutions. The results showed that previous washing with ammonium sulphide increases the action of distilled water on copper when exposed in open vessels, but lessens it when air is excluded, while in the case of saline solutions the action is diminished even when air has free access.

Muir has studied the action of various saline solutions upon lead, from which he draws the general conclusion that the action upon lead of those saline solutions which he has examined results, in the first place, in the production of a salt other than the hydrocarbonate; that carbon dioxide, slowly absorbed from the air, produces hydrocarbonate, which is precipitated; and that certain salts, such as ammonium nitrate and calcium chloride, accelerate the production of the soluble lead salt.

Hermann has made an extended investigation on the tantalum group of metals, and has discovered a new metal in this group, which he calls *Neptunium*, and which has an atomic weight of 118. The mineral in which the metal was detected was columbite, from Haddam, Connecticut.

The same investigator takes occasion to reaffirm the genuineness of his discovery of another metallic element, *Ilmenium*, announced some years ago. This announcement was at the time strongly opposed by the eminent chemists Rose and Marignac, and with such plausibility that Hermann publicly withdrew his claim to a new discovery. Hermann, in the same publication in which he announces the discovery of neptunium, takes occasion to reaffirm the genuineness of his former discovery of ilmenium, and points out that his eminent critics were in error, having been misled by employing impure materials.

Close upon the above-named highly important announcements of Hermann comes the publication of a communication by M. Prat, made to the Société des Sciences Physique et Naturelles de Bordeaux, in which he claims also to have discovered a new metallic element, which he names (in honor of Lavoisier) *Lavoesium*. The author appears to have isolated the metal, which is described to possess a silvery white color and eminent malleability. It forms crystallizable and colorless salts. It appears, according to the author, to be related to copper in many of its reactions. He affirms, however, that its spectroscopic behavior, its silvery white color, and its reactions with ammonia and ferro-cyanide of potassium constitute properties which distinguish it from every other known metal.

Duvillier has proposed a process for recovering from platinum precipitates and residues the metal contained in them, which consists in placing them in a boiling solution of sodium hydrate, to which is gradually added a solution of sodium formate. The liquid effervesces and deposits the platinum in a pulverulent form, whence it can be converted directly into chloride.

H. Sainte-Claire Deville and Debray have prepared ruthenium in a pure form, and have carefully examined its properties. Its density they find to be 12.261. A number of new compounds of this metal are described. They also prepared pure osmium, and find that is the heaviest of the platinum metals, its density being 22.447.

ORGANIC.

Kopfer has proposed the use of finely divided platinum, either in the form of sponge or black, for the filling of combustion tubes in organic analysis, instead of copper oxide, the combustion being carried on in a stream of oxygen. For ordinary purposes the tube is only thirty-five centimeters long, fifteen centimeters being filled with the platinum mixed with asbestus. Only three burners are necessary to heat the tube, a fourth being used to heat the substance. The results obtained by the method are apparently good.

Friedel and Crafts have proposed a new and general method for the synthesis of hydrocarbons, which consists simply in treating organic chlorides with aluminum chloride. If a

mixture of a hydrocarbon and a chloride be treated in this way, as, for example, a solution of amyl chloride in benzene, hydrogen chloride gas is evolved, and the liquid separates into two layers, the upper containing the resulting hydrocarbon—in this case amyl-benzene, dissolved in the excess of benzene—and the lower the unaltered aluminum chloride. Ethyl-benzene, methyl-benzene (toluene), dimethyl-benzene (xylene), trimethyl-benzene (mesitylene), tetramethyl-benzene (durene), diphenyl-methane, triphenyl-methane, and even tetraphenyl-methane have been made in this way, as well as benzophenone, acetophenone, phthalophenone, anthraquinone, and other acetones. The chlorides of zinc and of iron (ferric chloride) have a similar but less energetic action.

Latschinoff has proposed to establish a new series of homologous bodies, the successive terms of which shall differ from the preceding ones by C_5H_8, instead of CH_2, as in ordinary homologues. Camphor and the terpenes belong to such a series, and hence the author proposes to denominate the series a ter-homologous or a campho-homologous series.

Pierre has communicated to the French Academy his experiments to test the question of the existence of sugar in the leaves of the sugar-beet, where it is undoubtedly elaborated. The difficulty of extracting the sugar as such led him to adopt the much simpler method of fermenting the entire juice, distilling off the alcohol, and calculating from this the amount of sugar present. From 158 kilograms of leaves, coarsely chopped, thirty to thirty-five liters of juice were expressed, which, after fermentation for five or six days, yielded on distillation 275 cubic centimeters of alcohol of 68 per cent., corresponding to 198 cubic centimeters of absolute alcohol. Hence the leaves from one hectare of ground would yield 173 liters of absolute alcohol. This corresponds to 350 kilograms of sugar per hectare.

Prunier has continued his researches upon quercite, and has obtained other products than benzene in reacting upon it by excess of hydriodic acid. Among these are hexyl hydride, quinone and hydroquinone, and phenol. The author hence regards this sugar as intermediate between the fatty and the aromatic series.

Bente has identified the sugar obtained by boiling carrageen moss with very dilute sulphuric acid for a long time

with levulose. It reduces silver and copper solutions, forms oxalic acid when oxidized by nitric acid, does not crystallize, and rotates the polarized ray to the left, though its rotatory power appears to be weak.

Krusemann has studied the reduction-products of levulose, and at the same time those of glucose, in order to compare these two sugars together. The reduction was effected by sodium-amalgam, and the substance obtained was the same for both, and identical with mannite. The constitutional formula proposed by Fittig for this body will require modification.

Berthelot several years ago discovered a new complex sugar in the Briançon manna, an exudation from the larch, to which he gave the name of melezitose. Villiers has now identified with this a sugar obtained from Lahore, and there known as turanjbin, being an exudation from *Albagi maumorum*, a spiny bush belonging to the leguminosæ.

Vincent has examined the products obtained by the dry distillation, in close vessels, of the residue left after fermenting beet-root molasses, called vinasse. He has identified methylamine, methyl alcohol, sulphide and cyanide, hydrocyanic acid, formic, acetic, propionic, butyric, valeric, and caproic acids, phenol, and a series of liquid bases.

Brunner and Brandenburg have succeeded in detecting succinic acid in the juice of unripe grapes. They were led to examine for it by the fact that nascent hydrogen, acting on ethyl oxalate, produced tartaric acid and glycolic acid. The same reduction process the authors believe, therefore, to go on in the plant.

Hermann has observed an interesting and novel formation of salicylic acid by the prolonged action of sodium on succinic ether. Since succinic acid belongs to the fatty series, while salicylic acid belongs to the aromatic, the result is a conversion of one into the other—a rare thing in organic chemistry. Moreover, the constitution of the former enables that of the latter to be fixed with certainty.

Perkin has effected a simpler synthesis of coumarin (the odorous principle of the Tonka-bean, the melilot, etc.) by boiling salicyl hydride with acetic oxide and sodium acetate. With other aromatic aldehydes other syntheses were effected, some of them of great interest.

Baeyer, the successor of Liebig at Munich, has published

an extended memoir on the reaction of phthalic acid with the phenols, by which the curious new class of coloring matters, of which fluorescein and eosin are examples, are produced. Several new bodies belonging to the phthalins and phthaleins of these phenols are described, the paper being one of great interest.

Krüger, a German chemist, suggests the substitution of fluorescein in place of litmus as an indicator in titration. The beautiful fluorescence of this substance completely disappears in the presence of the slightest trace of acid, and as quickly reappears in the presence of free alkali. The changes are marked and characteristic. Free carbonic and acetic acids, however, do not affect the solution. The reagent can readily be used with colored solutions.

Lippmann and Hawliczek have made an accurate comparison between the benzoic aldehyde of bitter-almond oil, from the almond, and that obtained synthetically from toluene. The two bodies were found to be both chemically and physically identical.

Gnehm some years ago discovered a new orange coloring matter, dipicrylamine, or more properly hexanitrodiphenylamine, the ammonium salt of which was, in 1874, brought into commerce. But quite unexpectedly its manufacture had to be intermitted because of its action upon the skin, which was strongly irritating, producing an eruption resembling that caused by croton-oil or tartar-emetic ointment. Finding now the new coloring matter in the market under the name of Aurantia, he calls attention to its poisonous properties. To this, Martius, one of the firm making it, replies, saying that any such effects are due either to impurities or to the idiosyncrasies of the persons poisoned, his product never having given any complaint. Gnehm in his answer mentions establishments where both his coloring matter and afterwards aurantia were used; in both cases the workmen were covered with the eruption of the skin spoken of.

Dale and Schorlemmer have shown that red aurin, or peonin, as it is sometimes called, may readily be converted into rosaniline. If it be heated to 150° for some days with alcoholic ammonia, or for twenty hours to 120° with aqueous ammonia, a yellow solution is obtained, which contains a crystalline base, and deposits it on cooling. This base is

identical with rosaniline, giving the well-known fuchsin red with acetic acid, and yielding Hofmann's violet, aniline green, and aniline blue.

Wright has made a careful study of the alkaloids contained in the aconite family of plants. He finds in the roots of *A. napellus* the well-crystallized aconitine; though sometimes roots purchased for those of this species yield a bitter inert base, which he calls picraconitine. An uncrystallizable base is probably also present. The alkaloid of *A. ferox* is quite unlike aconitine, and is called pseudaconitine by Wright. He suggests that the numerous uncrystallizable products said to have been obtained from aconite were produced in the processes of extraction used.

Hesse has communicated a preliminary note, in which he says he has found, in a rare cusco bark, an alkaloid which appears to agree with the cusconine of Leverköhn, and to be closely allied to the aricine of Howard.

Glenard has investigated the alkaloid of ipecacuanha, emetine. It was obtained in small hemispherical warty crystalline masses, which, on purification, gave milk-white crystals. From the analysis of the alkaloid itself and of its chlorhydrate, the formula $C_{15}H_{22}NO_2$ is assigned to it.

PHYSIOLOGICAL.

Church has isolated and investigated the intense red coloring matter of *Coleus verschaffeltii*, using for this purpose half a hundred-weight of the plants. During the crushing process, alcohol mixed with sulphuric acid is added, and the crimson solution is filtered, shaken with barium carbonate, and the alcohol removed by distillation. A mass of deep red resinous substance sinks to the bottom, which is the coloring matter in question. When purified, it forms a brittle solid of resinous aspect, reddish purple in color, soluble in alcohol, slightly in water, having the composition $C_{10}H_{10}O_5$. The author believes it identical with many other red coloring matters of plants, especially with the œnolin extracted from red wine.

Bougarel has discovered a new red coloring matter in plants, which accompanies the chlorophyll, and which he calls erythrophyll. For preparing it, young peach leaves were extracted first with ether, the ether poured off, and

then with alcohol, and allowed to stand. After two days brilliant tabular crystals, green by reflected, red by transmitted light, appeared, which were soluble in benzene and chloroform with a red color.

Kosman has discovered in the buds of trees and the young leaves of many plants a natural ferment, which is capable of transforming cane-sugar into glucose, of converting starch into dextrin and glucose, and of resolving glucosides into glucose and some other body. The ferment was observed in the buds of elm, poplar, oak, and filbert, in the flowers of dogwood and the plum, and in the young leaves of chelidonium and digitalis.

Boussingault has detected the presence of sugar in the petals of several flowers, varying in amount from 7.22 per cent. in the oleander, through 5.00 in orange petals, 4.42 in portulacca, 3.80 in acacia petals, 3.40 in rose petals, 2.60 in lily petals, and 2.20 in rhododendron petals, to 1.44 in those of magnolia.

Pflüger has studied the influence of respiration on the metamorphosis of tissue, and maintains, in opposition to the view generally held, that the respiratory mechanism has no influence on the amount of the total tissue metamorphosis. With rabbits, he found that the absorption of oxygen in ordinary respiration is the same as during the most active artificial respiration. He believes that the amount of oxygen absorbed is a better index of the change of tissue than the carbon dioxide eliminated.

Cloëz has detected copper in the blood of two male deer killed wild in the woods. In the first case no special precautions were taken, but in the second the process was conducted with the greatest care, and three milligrams of copper oxide were obtained from 530 grams of blood. In the opinion of the author, the question of its origin is an interesting one, since the metal could have come only from the vegetables eaten or the water drunk by the animal.

Radziszewski has observed that light is emitted when certain aldehydes in alcoholic solution are agitated with potassium hydrate. He suggests that the phosphorescence of marine animals may be due to the formic aldehyde they excrete, which, oxidizing to formic acid, produces the sensation of stinging which they exhibit.

A series of experiments has been made by Vogel on the spectroscopic detection of carbonous oxide by means of a solution of blood. While the spectrum of pure blood is characterized by two bands in the green and yellow, which bands disappear and give a single broader band by the action of ammonium sulphide, blood which has absorbed carbonous oxide gas shows two similar but slightly more refrangible bands, not changing by ammonium sulphide. From his experiments, the author infers that he can detect 0.8 of one per cent. by volume of carbonous oxide in atmospheric air in this way with perfect certainty.

Cazeneuve has prepared pure hematin by treating defibrinated blood by commercial ether for twenty-four hours, then with more ether containing two per cent. of oxalic acid. This ether being saturated exactly with ether containing ammonia, deposits the hematin in flocks, which is purified by washing in water, alcohol, and ether. It combines with the haloid acids to form crystallized salts, and has the formula $C_{68}H_{70}N_8Fe_2O_{10}$. Concentrated hydrochloric acid splits it into two red bodies, one containing 37.62 per cent. of iron, the other 2.08 per cent.

TECHNICAL.

Berthelot has investigated more extensively the occurrence of benzene in coal-gas. Its presence there is due to the high temperature of the carbonization as well as to the prolonged heat, during which an equilibrium is established between the various hydrocarbons. If the distillation be effected at a low red heat, the gas may differ in its composition. The author's experiments were directed to ascertain experimentally the reliability of the method used by him in his analysis, *i. e.*, absorbing the benzene vapor by fuming nitric acid. The results of direct tests and also of endiometric comparisons were favorable, and established his assertion that in Paris gas benzene is the principal illuminant.

Humpidge, under Frankland's direction, has analyzed and tested the gas of London. He finds (1) that the gas now is no better than that analyzed by Frankland twenty-five years ago, and (2) that the apparent increase in its illuminating power is due solely to improvements in the test burner.

Mendelejeff has proposed a new hypothesis of the origin

of petroleum. Starting with the nebular hypothesis, the author regards the interior of the earth as metallic, doubtless composed largely of iron and carbides of iron. Through rents made by earthquakes, water gained access to these bodies at a high temperature and under great pressure; and by their mutual chemical action metallic oxides and saturated hydrocarbons resulted. These latter, carried by watery vapor, have spread themselves through the overlying rocks. He gives various geological and chemical facts which go to sustain his hypothesis.

Coquillion has reinvestigated the conditions under which a mixture of fire-damp and air explodes, originally determined by Davy. He finds the minimum quantity of air which will cause an explosion, when mixed with one volume of marsh gas, to be six volumes, and the maximum quantity sixteen volumes—a very wide range. He also observed that while the mixture producing the most violent explosion could be readily ignited by a flame or an electric spark, an ignited palladium wire, carried even to whiteness, caused no explosion, but only a rapid diminution of the gases.

Lawrence Smith has described, in the *Annales de Chimie et de Physique*, the gas-wells of Pennsylvania, giving analyses of the gases evolved, made for the State Geological Survey by Professor Sadtler, of the University of Pennsylvania. The marsh gas varies in these products from 60 to 89 per cent., the hydrogen from 4.79 to 22.5 per cent., and the ethylene from 4.39 to 18.12 per cent. Carbonic acid is also present.

A committee of the Paris Board of Health has just made a report to the Prefect of Police upon cremation, conceding its feasibility and general advantages, but objecting that it is too ready a means of concealing the evidence of crime.

Gladstone has examined some candles recovered from the wreck of a vessel sunk off the Spanish coast in 1702, and which have been in sea-water for 173 years. He found that about half the fat had been converted into soaps of calcium and sodium by the slow replacement of the glycerin. The calcium salt was in excess of the sodium salt.

Boutmy and Fancher have proposed a new plan for the manufacture of nitroglycerin, by which they have succeeded in making it in large quantities without developing the heat

which is so dangerous to the ordinary process. First, sulphoglyceric acid is made by treating glycerin of 30° by three times its weight of sulphuric acid of 66°. Second, nitrosulphuric acid is made by mixing equal weights of nitric acid at 48° and sulphuric acid at 66°. After cooling these liquids separately, they are mixed so as to get 100 parts of glycerin, 280 of nitric acid, and 600 of sulphuric acid. The temperature never rises more than 10° to 15°, and the nitroglycerin may be directly decanted and washed. The yield is from 160 to 195 per cent.

A paper has appeared by Bischof, giving the results of his examination of a considerable white efflorescence upon the outside of a tube which had been employed for eight months in conveying aqueduct water into a cistern, the tube being alternately exposed and immersed. The powder was lead carbonate and sulphate. On analyzing the tube itself, it was found to contain 1.7 per cent. of antimony. The author attributes the rapid corrosion to the presence of this metal, and considers the use of lead alloys for tubes for conveying drinking-water to be reprehensible.

Heeren has examined various kinds of caoutchouc to ascertain their solvency in coal-tar benzene. He finds the most soluble to be that of Guayaquil, of which benzene dissolves 20 per cent.; while that of Para has only 17 per cent. of soluble matter; Africa, 12.7; Rangoon, 9.1; and Madagascar, 5.7. Obviously this gum must be, therefore, a mixture of several different chemical substances.

Berthelot has given a description and an analysis of an ancient wine, fifteen or sixteen centuries old, obtained from an hermetically sealed earthenware vase in the Borely Museum at Marseilles. It came originally from Aliscamps, near Arles, in a vicinity used as a cemetery during the Roman epoch. It contained about twenty-five cubic centimeters of a yellowish liquid of a vinous aromatic odor and a hot, strong taste. On analysis it yielded, per liter, 45 centimeters of alcohol, 3.6 grams fixed acids (calculated as tartaric), 0.6 hydropotassium tartrate, 1.2 acetic acid, calcium tartrate and acetic ether, traces. The wine appears to have been buried with the dead.

Baudrimont has given a simple method for recognizing the presence of fuchsin (aniline-red) in wine. A drop is placed

on the hand and allowed to remain there a few seconds. On removing the wine, a mark is left which cannot be washed out with water.

Jacquemin has examined the methods proposed for the detection of fuchsin in wine, founded on its tinctorial power. As is well known, this substance is extensively used for this purpose. Pyroxylin and wool may be dyed directly in the wine, but to prove the presence of fuchsin finally, the ammonia process is necessary.

Maumené has published an extended memoir on an improved method of alcoholometry for determining the strength of wines, by distilling them first after making them alkaline, and then the distillate after making it acid. The memoir discusses at length the effects of the various foreign matters present in wine upon the result, and concludes that the improved method leaves nothing to be desired.

Erismann has investigated very thoroughly the question of the contamination of the air arising from artificial illumination and the distribution of the carbon dioxide in close rooms. He finds that the injurious effect cannot always be calculated from the absolute amount of carbon dioxide present, since the quantity of the illuminating substance which always escapes unburned is variable with the temperature and the illuminant used. Moreover, the contamination bears no necessary relation to the amount of light obtained. The conclusions reached are: 1st, in every case of artificial illumination the air of a close room contains more carbon dioxide and organic matter than when no light is present; 2d, the proportion of marsh gas to carbon dioxide varies, not only with the nature of the burning material, but also in different strata of the air of the room when the same material is employed, the ratio being never constant; 3d, air should never contain more than 0.6 or, at most, 0.7 per thousand of carbon dioxide, otherwise products of imperfect combustion are present in large quantity; though, on the other hand, a small quantity of this gas is no evidence of freedom from these; 4th, the position of the air-stratum in which most products of combustion are found depends on the nature of the burning material, the higher strata being most impure when candles are employed, though the larger part of the carbon dioxide from combustion is removed by

ventilation; and, 5th, petroleum, when burned in well-constructed lamps, gives rise to less carbon dioxide, and, what is more important, to less imperfectly burned matter, than any other illuminating agent. For equal light, stearin candles render the air most impure, the proportion for petroleum, gas, oil, and candles being 1 : 4 : 4 : 7. An ordinary room of a capacity of 100 cubic meters would contain, if lighted with petroleum (the light being equal to six candles), 56 cubic centimeters of carbon dioxide and 1.7 of marsh gas; if lighted with gas, 47 and 6.9 cubic centimeters; with oil, 109 and 7.2 cubic centimeters; and with candles, 125 and 18.7 cubic centimeters; the cost of the petroleum for 24 hours being 5 cents, of the gas 13 cents, of the oil (rape oil) 15 cents, and of the candles 72 cents.

Coquillion has proposed a new method for detecting and estimating the amount of fire-damp in mines. As is well known, the blue aureole which surrounds the flame of the safety-lamp when in an explosive atmosphere is the only means at present in use for ascertaining the presence of fire-damp, but this requires at least 6 to 8 per cent. of marsh gas to produce the effect. The new method is founded on the fact, first observed by him, that hydrogen and hydrocarbons generally are completely burned in presence of oxygen, and without detonation, by means of a palladium wire brought to a white heat. The carbon dioxide thus generated is afterwards estimated in a graduated tube. Two pieces of apparatus have been made—one for use in the mine, which detects the carbon dioxide produced by the incandescent palladium, and thus shows the fire-damp; the other for use above ground, in determining accurately the amount present.

Bischof has examined the action of spongy iron upon the low forms of organic life which form the specific poison of cholera, typhoid fever, etc. He finds that bacteria are rendered permanently harmless when passing into water through spongy iron. Even effluent sewage water, after passing through the spongy iron, remained perfectly clear for five years, though exposed to both light and air. The author asserts that the action of this material consists largely in the reduction of the ferric hydrate, the ferrous compound resulting being again oxidized by the oxygen in the water.

MINERALOGY.

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RECENT PUBLICATIONS.

Prominent among the contributions of the past year to the literature of mineralogy stands the tenth edition of Naumann's standard work. It is not too much to say that, since the publication of the first edition in 1846, it has always occupied the foremost place among German Mineralogies. The author closed his long and active career in November, 1873, just as the ninth edition of his work had been given to the public. The present edition has been prepared by Professor Zirkel, of Leipsic, well known for his many contributions to the subject of microscopical lithology. He has retained the general arrangement of the book, but has changed the method of classification, adopting the much-to-be-preferred chemical system in the place of that employed by Naumann. This, it need hardly be added, increases much the value of the work.

A second volume of Rosenbusch's "Mikroskopische Physiographie der Mineralien und Gesteine" has recently appeared. The first volume, devoted to the description of the microscopical characters of the important minerals, was published in 1873. The second part of the work is somewhat more extensive than the former, running to about six hundred pages, and is devoted to lithology. Both volumes derive much of their value from the fact that they embody the results of the author's own extended researches. Professor Zepharovich, of Prague, has edited a series of large crystallographical figures designed for class instruction. They include the most important crystalline forms under the different systems, and are drawn on so large a scale as to be adapted for wall-charts, in which form they will doubtless be found very useful.

The publication of a new edition of Kenngott's Mineralo-

gy, and the appearance of a mineralogical treatise by Pisani in Paris, are also deserving of mention.

In this country there has appeared a second "Report of the Mineralogy of Pennsylvania," by Dr. F. A. Genth; also Dana's "Text-book of Mineralogy," a work of about five hundred pages; and a new edition of Weisbach's Tables edited by Professor Frazer.

The new journal (*Zeitschrift für Krystallographie*) published by Professor Groth in Strasburg has now completed its first year, and has more than fulfilled the promises of the prospectus alluded to in the last volume of the *Record*. The first volume, in six numbers, covers about six hundred and fifty pages, with a large number of plates. It contains many valuable papers, as would be expected; but, perhaps more important than these, it includes also abstracts of most of the mineralogical memoirs published during the year, not only in other German periodicals, but also in English, American, French, Italian, Spanish, and Swedish journals. It thus furnishes a quite complete record of the progress of the science during the year.

The Mineralogical Society of Great Britain and Ireland has now issued six numbers, containing the records of its meetings, and also a number of original contributions.

FOREIGN RESEARCHES.

Of the many foreign mineralogical memoirs, mention can be made only of a very few; reference must rather be made for them to the journals that have been spoken of, as well as to the many other older and well-known publications. A list of the new species which have been described is given on a following page.

Mr. H. C. Sorby has added to his many important memoirs a most valuable research—"On the Determination of the Chief Optical Constants of Minerals by Means of a New Class of Optical Properties." It is published in No. 6 of the *Mineralogical Magazine*. The method consists in the determination, in thin sections of minerals, of their mean refractive index by simple observations with the microscope. Briefly described, this is done by measuring the amount of displacement which the focus of a certain object, as a set of finely ruled parallel lines on glass, suffers when a highly refractive

transparent substance is placed over it. This measurement is obtained by determining with an appropriate scale (to $\frac{1}{1000}$ of an inch) the distance which the body of the microscope must be moved to bring the original object into focus. When this distance is known, and also the thickness of the object in hand, the index of refraction may be calculated by a simple equation. Mr. Sorby describes the method in full, showing how readily it may be applied and with what useful results. He also discusses some phenomena which were observed in the course of his experiments, and which led to the discovery of "a new class of optical properties." These phenomena are fully explained, in accordance with the known laws of refraction, by Professor Stokes in the *Proceedings* of the Royal Society, to which it is here only possible to make reference.

Des Cloizeaux has continued his optical examination of the feldspars, and has come to the interesting result that there exists a *triclinic* potash feldspar, having identically the same composition with the *monoclinic* potash feldspar — orthoclase. The new species is called by him *microcline.* He shows, moreover, that these two feldspars generally occur crystallized together, the one interpenetrating the other, often in successive parallel bands. The beautiful green feldspar called amazonstone is conspicuous for this association of the two species: it is also true of the chesterlite of Pennsylvania, and specimens from many other localities. On the other hand, the feldspar enclosing ægirite from Magnet Cove, Arkansas, is found to be pure microcline.

Another extended work on the feldspar group has been published by Professor Szabo, of Buda-Pesth, Hungary. His object is to make it possible to distinguish between the different species as they occur in rocks. The method is based upon Bunsen's "Flame-reactions." It consists in part upon the accurate determination of the degree of fusibility, and in part upon the degree of coloration given to the flame, under different conditions, from which the amounts of sodium and potassium are estimated. The system is an ingenious one, and has been most carefully elaborated by the author; but it may be well questioned whether in hands less skilful than his it would yield any valuable results.

The important group of minerals embraced under the gen-

eral term of *micas* has been the object of some profound investigations by Kokscharof and Tschermak. Hitherto it has been customary to regard part of the micas as hexagonal (*e. g.*, biotite) and others as orthorhombic (*e. g.*, muscovite). The conclusion reached by Kokscharof, after the examination of many specimens of the different species, and a very long series of measurements, is that "the species are all *monoclinic* with an angle of 90° 0′ 0″." Tschermak concludes also that all the species belong to the monoclinic system, and assigns to them an angle of obliquity differing by a minute only from 90°. The latter mineralogist has also investigated with great care and minuteness the optical properties of the different species, and finds in them conclusive evidence of the monoclinic character of the crystals. He divides the species into two groups, according as the plane of the optic axis is (1) perpendicular, or (2) parallel, to the plane of symmetry. The first class includes the species muscovite, lepidolite, paragonite, and margarite, and a portion of the biotites to which he gives the name *anomite*. The second class includes phlogopite, lepidomelane, zinnwaldite, and the larger part of the magnesia-micas, or biotite, to which he gives Breithaupt's old name, *meroxene*. The second part of Tschermak's paper, including the discussion of the chemical composition of the species, has yet to appear, and will be looked for with interest.

Dr. Scharff, of Frankfort, has published another of his valuable crystallogenic memoirs upon calcite. He discusses the interior relation between the different crystalline forms of the species, and deduces from them some conclusions in regard to the genetic origin of the crystals.

Of other important memoirs may be mentioned that of Schrauf upon the crystallography of brookite and of lanarkite; by Vom Rath, upon the crystalline form of gold, upon rutile, etc.; of Strüver, upon the minerals of Latium.

AMERICAN RESEARCHES.

A considerable number of new minerals, described by American mineralogists, are included in the following list. In addition to them, many other papers of more or less importance have been published.

The rare minerals of the tantalite and columbite group, spoken of in a former issue of the *Record* as having been

discovered in North Carolina, have been the object of several researches. Dr. Smith has published an extended paper upon this subject. He describes and gives analyses of the columbite from Mitchell County, N. C., and also that associated with the Colorado amazonstone; of the samarskite of the same locality (first analyzed by Miss Ellen H. Swallow); of a mineral he calls euxenite. He also makes two new minerals, *hatchettolite* and *rogersite*, mentioned below. He, moreover, describes the fergusonite from the granite of Rockport, Mass.

Professor O. D. Allen has also published analyses of the samarskite and hatchettolite, which serve to fix their chemical character, as he gives the first determination of the amount of tantalic acid in each. Professor Delafontaine has investigated the samarskite, and announces that he finds in it about 25 per cent. of tantalic acid, a small percentage of thorium and didymium, also a little erbia, and more of the earth called by him *terbia*.

In connection with the above minerals, it is interesting to note the discovery, by Professor Eugene A. Smith, of the mineral tantalite in Alabama; and, by Professor W. C. Kerr, of several *uranium* minerals at the samarskite localities in Mitchell County, N. C. These are uranium mica, gummite, and uraconite (uranium ochre). Further than this, another new columbite, *sipylite*, is mentioned in the list beyond as having been described by Professor Mallet from the allanite locality in Virginia.

Dr. F. A. Genth has published another memoir upon American tellurium and vanadium minerals. He describes several new species—*coloradoite*, *magnolite*, *ferro-tellurite* (mentioned below)—and also describes the occurrence of native tellurium, tellurite, hessite, and calaverite from several new localities in Colorado. He mentions, too, the discovery of a green mineral, allied to the vanadium silicate *roscoelite*, from the Magnolia District, Col.

The same author, in the second "Report of the Mineralogy of Pennsylvania," publishes an analysis of the feldspar called *cassinite*, by Dr. Lea, showing that it contains 3.7 per cent. of baryta. This point is of special interest, as Des Cloizeaux has also recently mentioned the occurrence of a feldspar containing 7.3 per cent. of the same earth.

Professor B. Silliman has described an interesting and rare occurrence of gold interspersed in massive scheelite from Charity Mine, Warren's, Idaho Territory; and also another similar case from the Golden Queen Mine, Lake County, Col., where the gold appears in minute crystalline granules in the scheelite.

Mr. Samuel L. Penfield has given an analysis of the triphylite from Grafton, N. H., which serves to establish the correct formula of the mineral.

Professor A. H. Chester has shown that the so-called peganite of Arkansas is identical with the mineral called variscite by Breithaupt, and callainite by Damour. He has also described a remarkable fibrous variety of sepiolite from Utah, some of which is colored bright green by oxide of copper.

Dr. Koenig has described the occurrence of the rare minerals astrophyllite and arfvedsonite from El Paso County, Col., and has given analyses of both, as also of the zircon associated with them. He has also identified the new mineral strengite (see beyond) at Rockbridge, Va., and has published the results of a crystallographical and chemical examination of it. He has also given the name *protovermiculite* (see beyond) to a hydrated mica.

Professor G. C. Broadhead has described remarkable crystals of barite from the Last Chance Mine, Morgan County, Mo., and also the occurrence of göthite in limestone concretions from Adair County, Mo.

Garnets of the variety melanite have been found associated in an interesting way with magnetite, apatite, and altered pyroxene on the surfaces of the columnar trap of East Rock, New Haven, Conn.; and also the variety of garnet called topazolite, having a complex crystalline form, at the junction of the trap and sandstone of Mill Rock, New Haven.

Professor H. Carrington Bolton has made an extended examination of the effect of organic acids upon a large number of different minerals. The results are varied and interesting, and suggestions are made from them in regard to the application of some of the acids in the determination of minerals. Mr. J. H. Caswell has added to Professor Bolton's paper a description of the microscopic crystals produced in some of the reactions.

NEW MINERAL SPECIES.

The following is a list of the species recently introduced as new into mineralogy. They are arranged, for convenience of reference, in alphabetical order:

Aglaite.—A hydrous silicate from Chesterfield, Mass.; described by Julien. Related to pihlite (cymatolite of Shepard).

Amesite.—Described by Professor Shepard as occurring with diaspore at Chester, Mass. It is found in hexagonal plates and in foliated masses, having the color and lustre of some green talc. An analysis by M. Pisani, of Paris, shows the mineral to be a hydrous silicate of iron, aluminum, and magnesium. It is remarkable for the low percentage of silica (22 per cent.).

Anomite.—A name given by Tschermak to a portion of the biotite micas, particularly those of Lake Baikal, in the Ural. They are distinguished optically, as explained above, from the others which he embraces under the name of *meroxene.*

Arsenargentite.—According to Hannay, an arsenide of silver (Ag_3As). It occurs in orthorhombic crystals, of acicular form, in a mass of metallic arsenic, associated also with some rose quartz. Locality uncertain—perhaps Freiberg.

Bismutosphærite.—A carbonate of bismuth found at Neustädtel, near Schneeberg, Saxony. It appears in spherical and hemispherical forms with concentric structure. The color varies from yellow to brown and black. The specific gravity is high—viz., 7.3. According to Weisbach, who describes the species, it is identical with the original "arsenical bismuth" of Werner.

Bowlingite.—A problematical species from Bowling, on the Clyde, in Scotland. It is probably a decomposition product of the mineral chrysolite. It has a deep-green color, is semi-transparent, and has the hardness and feel of steatite. An analysis of the mineral by Hannay, and another by Young, give very different results, so that no dependence can be placed upon the species.

Bunsenine; Krennerite.—A telluride of gold from Nagyag, in Transylvania, has been called "Bunsenin" by Krenner. As the name *Bunsenite* has already been given to another mineral, Vom Rath has proposed to call the new

species *Krennerite.* It occurs with sylvanite and petzite in minute silver-white crystals, which have been thoroughly described by Vom Rath.

Coloradoite.—Found with native gold and tellurium at several mines in Boulder County, Col. It is, as described by Dr. F. A. Genth, a telluride of mercury (HgTe) analogous to the long-known sulphide (cinnabar) and selenide of mercury (tiemannite). It is found only massive, without cleavage, and has a metallic lustre and iron-black color. The specific gravity is 8.627.

Cryptocallite.—A new hydrous silicate of zinc and aluminum, described by Dr. G. E. Moore as occurring at the zinc-mines of Franklin, N. J.

Cuspidine.—A fluo-silicate of calcium, described by Scacchi, who discovered it at Vesuvius. It appears in spear-shaped crystals of a pale-red color.

Dysanalyte.—Found in cubical crystals in the granular limestone of the Kaiserstuhlgebirge in Breisgau, where it has long been known under the name of perofskite. Knop finds it, on analysis, to be a columbo-titanate of iron, calcium, cerium, and sodium, and separates it from allied species under the name of dysanalyte. This name refers to the difficulty involved in the chemical analysis of the mineral.

Elroquite.—A problematical phosphate of iron and aluminum, named by Professor Shepard. It occurs on the island of Elroque, Caribbean Sea. It is massive, and has an apple-green to gray color: the green color is attributed to chromium in combination with phosphoric acid, and the compound is called *phosphochromite.*

Enysite.—Occurs in stalactitic forms, of a bluish-green color, in a cave at St. Agnes, Cornwall. Its most prominent constituents are copper, alumina, water, and sulphuric acid (8 per cent.). It is supposed by Collins, the describer, to be of comparatively recent origin.

Ferrotellurite.—Observed by Dr. Genth as a crystalline coating on quartz, from the Keystone Mine, Colorado. Under the microscope it is seen to consist of minute prismatic crystals of a yellow color. In composition it is probably a tellurate of iron.

Franklandite.—A hydrous borate of sodium and calcium, found with ulexite at Tarapaca, Peru. Described by Professor J. Emerson Reynolds.

Ginilsite.—A name given by Rammelsberg to a massive mineral from the Ginilsalp in Graubünden, Switzerland. Its color is grayish-yellow, and its most prominent constituents are silica, lime, and iron, together with smaller amounts of alumina and magnesia, and 3 per cent. of water.

Guanajuatite.—The mineral *frenzelite*, mentioned in the *Record* for 1876, was described under the name of guanajuatite by Professor Fernandez in 1873, and the latter name has consequently the prior claim.

Haddamite.—A mineral occurring imbedded in the Haddam columbite, and believed by Shepard to be distinct from microlite.

Hatchettolite.—A name given by Dr. J. Lawrence Smith to a mineral occurring in regular octahedrons with the samarskite of Mitchell County, N. C. It has a yellowish-brown color and resinous lustre. Analyses by Dr. Smith, and a later and more complete analysis by Professor O. D. Allen, show the mineral to be essentially a tantalo-columbate of uranium and calcium, containing also some water, iron, and less than 2 per cent. of titanic acid. It is named in honor of the English chemist Hatchett, who discovered the element columbium.

Henwoodite.—Essentially a hydrous phosphate of aluminum and copper; described by Collins from the West Phenix Mine in Cornwall. It occurs in globular masses of a turquois-blue color on limonite.

Hetærolite.—Closely associated (hence the name from ἑταῖρος, *companion*) with chalcophanite at the zinc-mines of Sterling Hill, N. J. It occurs in botryoidal coatings, of a black color. In composition it is, according to Dr. Moore, a zinc hausmannite.

Heubachite.—A hydrated oxide of cobalt and nickel; described by Sandberger as occurring in thin coatings on barite at the mines in Heubach, near Wittichen, Baden.

Hexagonite.—Described as a new mineral by Goldsmith, but shown by Koenig to be a manganesian variety of tremolite, from St. Lawrence County, N. Y.

Homilite.—Found in orthorhombic crystals, of a brownish-black color, at Stockoe, near Brevig, Norway. In composition, according to Paijkull, it is allied to datolite, being a silicate of calcium and iron containing 18 per cent. of boracic acid.

Hydrocastorite.—A decomposition product of the castorite of Elba, which it surrounds as a white mealy coating. An analysis by Grattarola shows it to consist of silica, alumina, lime, and water.

Hydroniccite.—(See *niccochromite*, below.)

Krennerite.—(See *bunsenine*, page 157.)

Lawrencite.—A name given by M. Daubrée, in honor of Dr. J. Lawrence Smith, to the protochloride of iron, which he has separated from the Greenland iron.

Ludlamite.—A hydrous phosphate of iron, allied to vivianite, occurring in small monoclinic crystals, of a clear green color; described by Field from the mines of Cornwall, England.

Magnolite.—Occurs in white silky needles, having, according to Dr. Genth, the composition of a tellurate of mercury. Locality, Keystone Mine, Magnolia District, Col.

Meroxene.—An old name of Breithaupt, now given by Tschermak to a part of the biotite micas. (See above, *anomite.*)

Microcline.—A name early given to a variety of orthoclase: it is now appropriated by M. Des Cloizeaux for a feldspar identical in composition with orthoclase, but *triclinic* in form. It includes the feldspar enclosing ægirite from Magnet Cove, Ark.; and is intimately associated with orthoclase at many localities, conspicuously so in the beautiful amazonstone of Colorado.

Neochrysolite.—A manganesian variety of chrysolite, described by Scacchi as occurring in cavities in the lava of 1631 at Vesuvius.

Niccochromite.—Occurs as a thin yellow coating on chromite at Texas, Pa.; supposed by Professor Shepard to be a dichromate of nickel. Another associated mineral is regarded as a hydrate of nickel, and the name hydroniccite is suggested for it.

Pelagite.—A provisional name, proposed by Professor Church, for the material constituting the "manganese nodules" obtained by the *Challenger* in deep-sea soundings in the Pacific. They contain manganese, iron, alumina, and silica.

Phosphochromite.—(See *Elroquite*, page 158.)

Plumbomanganite.—A mineral examined and named by

Hannay. Color, dark steel-gray; composition, a sulphide of lead and manganese; locality unknown.

Protovermiculite.—A hydrous micaceous mineral from Magnet Cove, Ark.; closely related to culsageeite; described by Dr. Koenig.

Polydimite.—Occurs in regular octahedrons, of a steel-gray color and brilliant metallic lustre. According to Laspeyres, it is essentially a sulphide of nickel (R_4S_5), though quite distinct from millerite. Locality, Sayn-Altenkirchen.

Rogersite.—A new hydrous columbate of yttria, named by Dr. J. L. Smith in honor of Professor William B. Rogers. It occurs as a white incrustation, with mammillary structure, upon the samarskite of Mitchell County, N. C.

Silaonite.—A selenide of bismuth (Bi_3Se); described by Professor Fernandez as occurring with guanajuatite at the mines of Guanajuato, Mexico.

Sipylite.—A new columbate, of complex composition, occurring, as described by Professor Mallet, with allanite of Amherst County, Va. It contains as bases zirconium, erbium, yttrium, lanthanum, cerium, didymium, uranium, iron, and calcium, with smaller amounts of other elements. It occurs indistinctly crystallized, has a brownish-black color and a resinous lustre. Its specific gravity is 4.89. It is remarkable for glowing very brilliantly in the blowpipe flame.

Sonomaite.—A hydrous sulphate of aluminum and magnesium collected near the geysers of Sonoma County, Cal., and described by E. Goldsmith. It appears in colorless crystalline masses with silky lustre.

Sphærocobaltite.—Found in spheroidal forms, with roselite, at Schneeberg, Saxony. Its color is rose-red, and in composition it is a carbonate of cobalt ($CoCO_3$). Described by Weisbach.

Strengite.—A hydrous phosphate of iron, allied to scorodite. It occurs with cacoxenite in spherical incrustations of a generally white color. Described by Nies as found at the iron-mines near Giessen, Hesse; and since identified by Koenig from Rockbridge County, Va.

Szmikite.—A hydrous sulphate of manganese; described by Schroeckinger as occurring in stalactitic forms at Felsobanya, in Transylvania.

Uranocircite.—Described by Dr. Weisbach as a hydrous

phosphate of uranium and barium, in appearance very similar to autunite. Occurs in quartz veins in the granite of Falkenstein, Saxon Voigtland.

Venerite.—A name given by Dr. T. Sterry Hunt to a hydrous silicate of copper, which forms the mass of the "clay ore" mined in Berks County, Pa.

Waluerite.—A hydrous silicate of aluminum, calcium, and magnesium, allied to xanthophyllite; in external appearance very similar to clinochlore. Described by Kokscharof as occurring near Achmatowsk, in the Southern Ural.

Youngite.—A hypothetical mineral of unknown locality, supposed by Hannay to be a sulphide of zinc, manganese, and lead.

Zircarbite.—A massive yellowish-brown mineral, of unknown chemical composition, occurring at the granite quarries of Rockport, Mass. Named by Professor Shepard.

METEORITES.

M. Daubrée has carried on a series of experiments with dynamite, investigating the effects produced upon a block of steel when a charge has been exploded upon it under different conditions. The object of these experiments was to obtain an explanation for some of the most commonly occurring characters of meteorites. The result of his investigations showed that the effects produced upon the steel which had been subjected to the explosion were throughout comparable to those produced upon the meteorites by their passage through the atmosphere of the earth. This was true of the irregular fragments formed, the pitted condition of the surface, the striations of the surfaces which had been rubbed together, the cracks, and the marbled surfaces.

The conclusion to which he comes, from the facts that have been stated, is that the meteorites owe their distinctive characters to the pressure of the atmosphere against them, as they move through it with immense velocity, and to the heat thus generated—this pressure being analogous to that which acted upon the steel at the moment of the explosion of the dynamite.

The so-called meteoric iron of Ovifak, near Disco, Greenland, has been the subject of several recent papers. A prominent one by Steenstrup deserves to be mentioned. He de-

scribes the method of occurrence of the iron very fully (he had twice visited the locality), and shows conclusively that the doubts that have been expressed in regard to the meteoric character of the iron were well founded, and that the iron is most certainly of *terrestrial origin.* The presence of the iron in the basalt is explained by the supposition that it has in part been brought up with the basalt, and in part formed subsequently in it by a process of deoxidation through organic matter. In support of the latter view, the writer mentions that with the native iron in the basalt, both at Aussuk and Ovifak, occurs a considerable amount of *graphite.*

It is interesting to note in this connection, though having nothing to do with meteorites, that Mr. G. W. Hawes has shown that native iron occurs in grains distinguishable under the microscope in the labradorite rock from the Washington River, in the White Mountains.

Of the meteorites which have been described during the past year, several deserve especial mention. M. Daubrée has described a meteoric stone which fell at Feid-Chair, province of Constantine, Algiers. The fall was accompanied by a loud noise, and the stone struck with such violence as to bury itself in the earth to a depth of nearly one hundred feet. It proved to belong to the class of meteorites which contain but little iron, the mass being made up of gray doubly-refracting silicates—probably chrysolite and enstatite. The same author has also published an analysis of a new meteoric iron from Santa Catarina, Brazil. It is remarkable for containing a larger amount of nickel (34 per cent.) than any other iron which has been described. It exhibited fine Widmannstättean figures, contains niccoliferous magnetic pyrites and graphite, and is covered with a thin but firm crust of crystallized magnetite.

A most interesting meteorite fell on the 21st of December, 1876, at Rochester, Fulton County, Ind. The meteor, or bolide, of which it was a part was observed in many places in the West in its passage eastward over the states of Kansas, Missouri, Illinois, Indiana, and Ohio. In the words of Dr. Smith, "the pyrotechnic display is said to have been transcendently beautiful, hardly equalled or surpassed by any previous occurrence of the kind." It was described as a

fire-ball surpassing the moon in apparent magnitude, followed by a great number of smaller meteors. An observer in Columbus, O., stated that "the color of the light was yellowish-red, resembling the light from the red balls of fire thrown out by the explosion of some kinds of fire-rockets." Although the display occasioned by the passage of the meteor through the air was so brilliant, only a very small fragment seems to have reached the earth: this was found by Mr. Norris lying on the surface of the snow near where he had noticed it to fall. It weighed about three fourths of a pound. The description of the stone as given by Professor Shepard and Dr. Smith shows it to be remarkable for its coarse pisolitic structure, resembling, according to the latter, the meteorite of Aussun, France.

Two other meteorites have been described by Dr. Smith as having fallen within a month of the one which has just been mentioned. These are the meteorites of Warrenton, Mo., and of Cynthiana, Ky. The former fell about sunrise on the 3d of January, 1877. In its passage through the air it produced a noise similar to the whistle of a distant locomotive; and in falling struck a tree, breaking off some of the limbs. When it reached the ground it was broken into a number of pieces, which were picked up while still warm. Some ten or fifteen pounds have been preserved. The stone has a uniform dark ash color, and is soft and easily crushed, which accounts for its being so much fractured in falling.

The bolide of which the Cynthiana meteorite was a part was seen brilliantly over portions of Indiana and Kentucky. The fall was accompanied with considerable noise, producing much consternation among the inhabitants of the surrounding country. The stone was seen to strike the earth, and was immediately dug up from a depth of thirteen inches, to which it had buried itself. Its weight was about fourteen pounds. In character it much resembled the well-known meteorite of Parnallee, India.

Dr. Smith has also published accounts of the Waconda, Ks., meteoric stone discovered in 1876, but the date of whose fall is not known; also of the Bates County, Mo., meteoric iron (1875), and that of Rockingham County, N. C., discovered in 1863.

GEOLOGY.

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GEOLOGY OF NEWFOUNDLAND.

The progress of geological investigation in North America may be conveniently introduced by considering some of the results of the labors of Mr. Alexander Murray in Newfoundland, which is geologically as well as geographically a continuation of the Atlantic belt of continental North America. Mr. Murray's geological map of the island, published within the last year, together with his annual reports, and some recent notes of Mr. Milne, edited by Murray, give the following facts not generally known.

Besides the considerable areas of Laurentian gneiss long since recognized, accompanied in some places by the characteristic crystalline limestones, are areas of Norian or labradorite rocks. In addition to these, there is met with a great series, which, holding a position between the Laurentian and the Cambrian rocks, was by Murray designated as the Intermediate series, and regarded by him as equivalent to the Huronian, which he had formerly studied on the shores of lakes Huron and Superior. These rocks are most widely developed in Newfoundland in the peninsula of Avalon, and are principally crystalline schists with quartzites and conglomerates, including what have been called cherty and jaspery beds. These latter, in some instances at least, the writer has found to be petrosilex rocks, like those of the continental portion of the Atlantic belt noticed in the report of last year (page xcvi). This Huronian or Intermediate series has been described by Murray as carrying in Newfoundland organic forms—*Arenicolites*, and a patella-like shell (*Aspidella*). These are, however, found in beds referred to the summit of the series, and perhaps belong to the overlying Lower Cambrian strata, which rest upon the crystalline rocks in patches of varying extent, and consist of sandstones, conglomerates, and

roofing-slates, passing upwards, without any visible break, into the so-called Lower Potsdam beds. These are fossiliferous slates and conglomerates, to which a thickness of 5400 feet is ascribed. Above them are other fossiliferous strata, assigned to the Calciferous sand-rock, to which succeeds a great mass of graptolitic slates referred to the Levis division of the so-called Quebec group, and containing the forms of the Arenig or Skiddaw of Great Britain. The fossiliferous strata of the Quebec group in Newfoundland are arranged in sharp folds running in a northeast direction, and are affected by great dislocations having a similar course. At the summit appears a great mass of what are described as igneous and magnesian rocks, composed of chloritic and hornblendic schists, with serpentines, which, according to Murray, seem "to be lapped over the inferior strata unconformably, and to come in contact with different members in different places." This crystalline series is identical with what had previously been described by the geological survey of Canada, both in the province of Quebec and in Newfoundland, as a part of the Quebec group in an altered state; the conformable succession being, in ascending order, according to Logan, Levis, Lauzon, and Sillery, so that these crystalline rocks were conceived to be the Lauzon and the Sillery in a metamorphosed condition. With this the observations of Murray are in contradiction. The Sillery which, in accordance with the views of Logan, should overlie conformably the magnesian series, or, rather, form its upper part, is found by Murray to overlie with perfect regularity the fossiliferous strata; but, in every case where a contact has been seen, the Sillery passes *unconformably beneath* the crystalline magnesian rocks. These, then, according to Murray, are not altered strata of the Quebec group, but a newer series resting in discordance upon it, eruptive in their origin, and intermediate in age between the time of the Quebec group and the Loraine shales. In fact, these crystalline strata are found unconformably overlaid by fossiliferous strata belonging to the Loraine and Clinton periods. The succeeding Niagara formation is represented at White Bay by 2800 feet of conglomerates and slates with limestones, and the Devonian by about 3700 feet of sandstones and slates with plant-remains. The Carboniferous, which is found in southwestern Newfoundland, has in one place a thickness of

over 6000 feet, and resembles closely that of Nova Scotia, including limestones and gypsums. The largest coal-seam found has a thickness of three and a half feet. The Carboniferous rocks rest upon the Laurentian and upon the Potsdam.

These crystalline rocks, which overlie unconformably the uncrystalline Levis and Sillery beds, and are in their turn overlaid unconformably by the uncrystalline Loraine shales, are described in more detail as consisting, besides the rocks already mentioned, of greenish feldspathic and hornblendic rocks, serpentines, diallages, argillites, talcose and chloritic schists, and rusty-weathering dolomites. They include the great copper-mines of Tilt Cove and Terra Nova, and are identical with the crystalline Huronian rocks of the Atlantic belt. Reference to the *Record* for 1876 (page xcviii) will show the evidence there adduced in favor of the view that the Sillery is really a lower division than the Levis; that the unaltered Quebec group, as hitherto described, is an inverted series, the normal position of the Sillery being below, and not above, the fossiliferous Levis division; and, finally, that the so-called altered Quebec group is an older crystalline series. It is pretty evident to those who have studied critically the Atlantic belt that the apparent uncomformable superposition of these crystalline rocks to the Sillery and Levis in Newfoundland is nothing more than the phenomenon—so often seen along this belt—of the older rocks overriding an overturned fold of the fossiliferous strata. It may be added, in this connection, that the work of the geological survey of Canada during the past year in the province of Quebec has shown the truth of the view so long maintained by the writer, that the crystalline schists of the Green Mountain belt are, in their normal position, found unconformably beneath the fossiliferous strata of the Quebec group. The relations sustained by them in Newfoundland to the Cambrian rocks, on the one hand, and the Siluro-Cambrian, on the other, can only be explained by admitting a period of disturbance, accompanied by folding, subsequent to the Chazy period and previous to the Loraine. This doubtless corresponds to the great continental movement, which, as we know, immediately preceded the deposition of the Trenton limestone in the St. Lawrence valley.

Milne, who has studied with Murray some of these points in the geology of Newfoundland, adopts the notion that the

whole of the crystalline series above noticed is of volcanic origin, and consists of the lava and ashes of volcanoes, which have since been altered into these crystalline schists. A like view of the origin of the similar Huronian rocks of Lake Superior was some years since put forth by Nicholson, and G. M. Dawson has also expressed the opinion that a series of rocks in British Columbia, apparently lithologically identical with these, is of Mesozoic age and of volcanic origin. There is nothing, however, in the chemical or lithological character of these rocks in central or in eastern America to support such an hypothesis, nor any good reason for believing in the possible transformation of lavas and volcanic ashes into such crystalline schists. These rocks, at least in the regions first mentioned, and in Europe, are Eozoic strata; and the various hypotheses of which, under the name of *pietre verdi*, they have been the subject in Italy for the last half century, are instructive in this connection (*Record* for 1876, page c). From these ancient crystalline rocks, we pass, by a natural transition, to the

PRE-CAMBRIAN ROCKS OF WALES.

Rising from below the Lower Cambrian (Harlech) strata at St. David's, in South Wales, is a narrow ridge of crystalline rocks, which was described by the geological survey of Great Britain as partly intrusive and partly altered Cambrian strata. Later studies by Hicks and Harkness have, however, shown that these crystalline rocks are marked by bedding-planes, and belong to two unconformable stratified series, the upper of which contains pebbles of the lower, while the basal beds of the unconformably overlying Cambrian present a conglomerate containing portions of both of these older series, which were clearly crystalline rocks before the deposition of the Cambrian. To the lower crystalline series Hicks has given the name of Dimetian, from Dimetia, an ancient kingdom including this part of Wales; and to the upper that of Pebidian, from Pebidiauc, the Welsh name of the hundred or district. The Dimetian rocks, which have a northwest strike, are nearly vertical in attitude, and have an estimated thickness of 15,000 feet. They are described as quartzose and feldspathic schistose strata, often greenish and purplish in color, with unctuous surfaces, besides thin

beds of impure dark-colored ferriferous limestone, holding a greenish mineral, designated as serpentine or chlorite. A section from one of the more silicious beds showed by microscopic examination quartz and orthoclase interwoven as in a graphic granite, together with a plagioclase feldspar and chlorite. The rocks of the Pebidian series, which, with a northeast strike, rest unconformably upon the Dimetian, are usually nearly vertical and sometimes inverted in attitude. The portions exposed from beneath the overlapping Cambrian strata show a thickness of about 3000 feet. Besides compact conglomerates, the materials of which are apparently derived from the ancient Dimetian series, the Pebidian rocks are somewhat vaguely described as consisting of stratified porcellanites, alternating with greenish and purplish schists. They are cut by dikes, which do not traverse the overlying Cambrian. Besides the locality at St. David's, Hicks has recognized several areas of Pebidian strata in that region, which have been heretofore mapped as altered Cambrian strata, and others which have been regarded as intrusive rocks.

ROCKS OF THE ARDENNES.

The crystalline rocks of the Ardennes have been the subject of microscopic study by De la Vallée-Poussin and Renard, according to whom many rocks hitherto regarded as exotic or eruptive, including hornblendic, euritic, and porphyritic masses, are really indigenous rocks, interstratified with the schists and quartzites of the region. They infer that these rocks were of aqueous origin, and became crystalline soon after their deposition.

GEOLOGY OF VERMONT.

J. D. Dana has called attention to the observations of the late Mr. Wing on the geology of Vermont. The facts are, however, for the most part, not new, and Mr. Wing's observations were examined and discussed by Billings and the present writer in the *American Journal of Science* in 1868. It has long been known that the folded strata along the western base of the Green Mountains included fossiliferous rocks of Trenton age, both in New York and Vermont, and in the province of Quebec. In the latter region, strata supposed by Logan to be at the base of the Quebec group, and to under-

lie the whole Green Mountain series, are of Trenton age, and owe their apparent position to overturned folds, accompanied in some places, apparently, by dislocations. In the province of Quebec they are involved both with the older crystalline strata and the Upper Taconic, but farther south, in Vermont, with the Lower Taconic series, which is, for the most part, concealed between Lake Champlain and Quebec. The crystalline limestones of this latter series in western New England have, by different geologists within the last twenty years, been referred to the Quebec group, to the Trenton, and to the Niagara or Helderberg—a history recalling that of the similar limestones of Italy which is told in the last year's *Record* (page xcix). In each case both stratigraphical and paleontological evidences have been appealed to in support of the various hypotheses, as in the similar and long-contested problems relating to the rocks of the Maurienne and Tarentaise in the Alps. Fossiliferous strata included in folds, or in faults, are supposed to fix the age of the entire series; and the absence of fossils from the other parts of the section is accounted for by the assumed metamorphosis of these portions of the strata. In more cases than one in the history of these rocks, forms not of organic origin have done duty as fossil remains. It is instructive, in this connection, to note the observation of Dana, that some slaty quartzites interstratified with limestones in Vermont exhibited "forms that looked exceedingly like casts of a *Pleurotomaria* and a *Murchisonia*, and of a valve of *Orthis lynx*." These, however, he admits to be only "imitative forms," due in some unexplained way to concretion. There are also, according to him, sections of long-chambered cylinders, as of "crinoidal stems, yet having the chambers too large and irregular for any known crinoidal forms." From supposed paleontological evidence, he now refers the whole belt of Lower Taconic rocks to the Champlain division, thus returning to the view long ago advocated by Mather, but rejected by Logan in favor of one, and by Adams of another, hypothesis—each of which has found its advocates in turn.

GEOLOGY OF WISCONSIN.

Irving has discussed the subject (alluded to in the last year's *Record*) of the imagined Paleozoic age of the Huronian rocks

of Lake Superior, and declares that the facts now established in that region show (1) the existence of an ancient gneissic and granitic system, regarded as Laurentian, which is overlaid unconformably by (2) a series of quartzites, schists, and diorites, with limestones and some gneiss and granites, referred to the Huronian. This is followed, probably unconformably, by (3) the copper-bearing series (Keweenian), which includes greenstones and melaphyres, and also great thicknesses of interstratified sandstones, shales, and amygdaloids, the whole having a thickness of several miles. These are finally covered unconformably by a series of unaltered horizontal sandstones, including numerous fossils related to those of the Potsdam sandstone. Irving observes: "As to any of the Wisconsin or Michigan crystalline rocks being altered equivalents of the Primordial and newer strata of the Eastern States, such an hypothesis is certainly untenable for a moment." And, while admitting that such things may be elsewhere, adds: "There certainly has been no period of metamorphism in the region of the Northwestern States since the beginning of the Primordial." Mr. Sweet, who has particularly studied the rocks of this region, finds the thickness of the Huronian, so far as observed, about 5000 feet. The Keweenian, which extends in the form of a great synclinal from Lake Superior westward across the whole State of Wisconsin into Minnesota (a length of over 300 miles, and from thirty to fifty miles wide), has a thickness of strata estimated at not less than 40,000 or 50,000 feet. The trappean rocks of this series, as seen at the Falls of the St. Croix, were, by Owen, regarded as more recent than the Potsdam sandstone. It is, however, shown by Sweet that the trappean rocks in question not only belong to a stratified series, but that the basal beds of the sandstone resting upon them are in part made up of the ruins of these rocks. These sandstones have yielded several species of *Conocephalites*, *Agnostus*, and *Dikellocephalus*, besides *Obolella* and *Lingulepis*.

EOZOIC ROCKS WEST OF THE MISSOURI.

Hunt has published some preliminary observations on the crystalline rocks of certain parts of the Rocky Mountains. The gneisses in the Colorado range as seen in Clear Creek cañon, and in the Sangre de Cristo range, near Garland,

have all the lithological characters of the Laurentian as displayed in the Laurentides, the Adirondacks, and in the South Mountain between the Hudson and Schuylkill rivers. They consist of gneisses frequently granitoid, often hornblendic, but scarcely micaceous, which are penetrated in the vicinity of Georgetown, Colorado, by well-marked granitic masses—probably exotic. Similar gneissic rocks are found in Glen Eyrie and the Ute Pass, in Colorado, where large masses are often highly granitic in aspect, with rarely interbedded gneissic layers. These rocks, which the writer regards, with Marvine, as indigenous, had already been by the latter observer compared with the Laurentian. The red granitoid rocks at and near Sherman are also by Hunt regarded as Laurentian gneisses. Labradorite rocks having the characters of the Norian series, and associated, like that series in the east, with large masses of titanoferrite, are known in Wyoming Territory.

The gneissic rocks of the Wahsatch range, as seen in the Devil's Gate on the Weber River, are also Laurentian, to which are referred the similar stratified rocks found in the same range farther south, in the upper part of the Little Cottonwood cañon. Here, among loose blocks of the gneiss, are found occasional masses of coarsely crystalline limestone with mica, and varieties of pyroxenic rocks characteristic of the Laurentian. In the lower part of the same cañon are, however, well-marked eruptive granites. The crystalline schists met with at the western base of the Sierras in Amador, Placer, and Nevada counties, in California, are described as having all the characters of the Huronian series as seen in Eastern North America and in the Alps. To this horizon, also, Hunt refers the similar crystalline rocks of the Coast range of California, as seen near San Francisco and near San José. The auriferous quartz veins in the counties above named are found traversing alike the Huronian schists and the granites of the region, which are, probably, newer than the schists.

EOZOIC ROCKS OF THE BLUE RIDGE.

Referring to the observations on the geology of North Carolina in the *Record* for 1875 (page c), we may notice that Hunt has given a preliminary account of his late observations in a section across the Blue Ridge through Mitchell

County, North Carolina. He finds that the gneisses of Roan Mountain, and the similar rocks at its western base, which include considerable masses of very pure magnetic iron ores, are Laurentian, but that there are indications of a belt of Huronian schists along the western border. These Laurentian gneisses to the eastward are succeeded by a great breadth of thin-bedded gneisses, with highly micaceous and hornblendic schists, which he refers to the Montalban series, to which belongs the narrow belt of dunite or olivine rock found on the line of section near Bakersville. These Montalban strata are intersected by numerous endogenous granitic veins, which are extensively worked for mica, and yield, moreover, finely cleavable orthoclase and albite, together with beryl, apatite, and the rarer minerals autunite and sarmarskite. The rocks of this series, often decomposed to considerable depths, were found to occupy the greater part of the country as far east as Salisbury, interrupted near Statesville, however, by granitoid gneisses of Laurentian aspect. The belt of granular quartzite associated with limestone, which is met with at the eastern base of the Blue Ridge on the Catawba River, near Marion, is referred to the Lower Taconic, of which it has the characters. Portions of this quartzite are granular and flexible, and constitute the rock known as flexible sandstone, or itacolumite. This granular quartzite is regarded by Hunt as identical with the Primal white sandstone of Pennsylvania. The gneisses of Bellisle, near Richmond, Virginia, are, according to this observer, to be referred to the Laurentian period.

GEOLOGY OF THE CINCINNATI ANTICLINAL.

Safford has pointed out the evidences that this anticlinal, which in Kentucky and Tennessee brings up between the Appalachian and Illinois coal-basins the limestones of the Trenton, was represented by an island during the Silurian age. There were two marked elevations along the line of this axis, of one of which Cincinnati is near the centre, while another is near Murfreesborough, Tennessee; a depression in Southern Kentucky separating the two.

The summit of the Cambro-Silurian series, represented by the Cincinnati shales, the equivalent of the Utica and Loraine of New York, is in the southern area directly overlaid by the

black shales of the Devonian. The Medina, the Clinton formation, with its dyestone or fossiliferous iron ores, and the Niagara and Lower Helderberg groups, were not deposited over this island-area, and in approaching it thin out, as might be expected. During the Medina and Clinton periods the land extended far to the west, while during the Niagara and Lower Helderberg times the extension was more or less easterly.

THE CARBONIFEROUS ROCKS IN KENTUCKY.

Shaler has considered the question whether the Appalachian and Illinois coal-fields were at one time connected. Both of these, as is well known, extend into Kentucky, of which they occupy respectively the eastern and western portions, and are separated by an interval of about seventy miles in the centre of that state. He has found, in the progress of the geological survey of Kentucky, that there are everywhere across the area evidences that the coal-bearing strata were at one time continuous. In numerous localities, at altitudes of from 250 to 300 feet above the nearest streams, are found débris, evidently derived from the coal-formation. These include numerous masses of cannel-coal, with fragments of the characteristic sandstones and conglomerates, and in some cases organic remains, which leave no doubt that these were derived from rocks of the coal-period; while farther to the southward were found evidences of the underlying millstone-grit. He points out that the conditions in which these occur are such as to exclude the notion that they are of the nature of drift, and maintains that they have been left by the waste of these formations by atmospheric agencies.

Newberry, in a recent report of his observations made in 1859, describes a similar remarkable example of erosion on a grand scale in the upper part of the Colorado plateau. Here, resting conformably upon the Carboniferous limestone, are the variegated sandstones and shales of the Lower Mesozoic, which pass upwards into the massive sandstones of the Lower Cretaceous. Above these were once spread not less than 2000 feet of soft shales belonging to the Middle and Upper Cretaceous, of which there now remain over great areas only occasional mounds of the strata, and vast numbers of organic remains scattered over the surface, the great mass of strata having been worn away by subaerial agencies.

THE ONTARIO SALT REGION.

The existence of a salt-bearing horizon known as the Onondaga or Salina formation, in the Silurian series in New York, between the Niagara and Lower Helderberg limestones, has long been recognized. The brines of Syracuse and its vicinity are, however, obtained not directly from this formation, but from an ancient gravel which fills an old lake-basin excavated on the outcrop of this formation; and the existence of rock-salt at this horizon was not demonstrated. In 1866, however, Hunt described the occurrence of rock-salt, detected in a boring at Goderich, Ontario, on the east shore of Lake Huron, and expressed the opinion that the deposit occupied a position identical with that which supplies the brines of Syracuse. In 1876 a boring to explore this salt was made at Goderich with a diamond drill to the depth of 1517 feet in horizontal strata, and from the cores he has been enabled to study the geology of this deposit. The Oriskany sandstone and the Lower Helderberg limestone, which are found in Eastern New York above the Salina formation, are here wanting, and the superficial strata at and near Goderich have been regarded by the geological survey of Canada as the base of the Upper Helderberg or Corniferous limestone. The salt was reached at a depth of 997 feet, beneath which were found 520 feet of red and brown marls, alternating with beds of anhydrite and rock-salt, the boring having been discontinued without reaching the base of the formation. Six beds of salt were met with, the thickest two being about thirty-one and twenty-five feet—the latter exceedingly pure. Above the rock-salt are still 121 feet of variegated marls, making in all 641 feet, followed in ascending order by 243 feet of dolomites with gypsum, making 884 feet supposed to belong to the Salina formation. To this succeed 276 feet of limestone, with layers of chert and with fossil corals; and, finally, 278 feet of dolomites like those below the limestone, but without gypsum. The organic remains of the limestone, so far as can be ascertained from the cores got in boring, resemble those of the Upper Helderberg, from which, however, they are separated by nearly 300 feet of dolomites, resembling those of the underlying Salina series, and perhaps corresponding to the Water-lime beds of New York. It is sug-

gested, in explanation of this, that there was a temporary depression of this western salt-area, permitting the deposition of the lower fossiliferous limestones from the outer ocean, upon the saliferous series; after which a second movement of the surface excluded the ocean for a considerable period while the upper dolomites were laid down, to be in their turn covered by the Corniferous limestone. A shaft now being carried down for the purpose of working these beds of rock-salt will permit the paleontological study of the question.

SUBTERRANEAN TEMPERATURE.

The observations on the temperature made in the deep boring at Sperenberg, near Berlin, in Prussia, have of late attracted considerable attention. The depth penetrated here is 4052 Rhenish feet (4172 feet English), the whole distance being in rock-salt, with the exception of the first 283 feet, which were in gypsum and anhydrite. The early observations were unsatisfactory, and, as since appears, incorrect. They showed a greatly diminished rate of increase in descending, from which Mohr reasoned to the absence of any subterranean heat. His conclusions are, however, rejected as fallacious by Dunker, to whom we owe the observations on the temperatures in this boring. The first determinations of the latter were found to be vitiated by the circulation of water in the bores, which, it was shown, was the cause of a considerable reduction of temperature. This source of error was subsequently obviated by the use of plugs at suitable distances; and, from the corrected observations thus obtained, it was found that although there were still considerable variations in the rate of increase, as determined for intervals of 200 feet down to 3390, the mean rate of increase in the temperature was one degree of Fahrenheit for 50 Rhenish or 51.4 English feet—a figure agreeing closely with those previously deduced from many observations in other localities. The rate of increase for the upper 700 feet, which were partly in gypsum and anhydrite, was found to be 3.24 degrees for each 100 feet, while for the distance from 2100 to 3390 feet it was only 1.49 degrees. From some recent experiments undertaken in connection with this problem, Herschel has found that the conductivity of rock-salt is exceedingly high, and, according to him, "theory shows that the rates of in-

crease in superimposed strata should be inversely as their conductivities;" so that the more rapid increase of temperature in the upper 700 feet of the Sperenberg boring may be attributed to the relatively small conductivity of the gypsum and anhydrite. It is not impossible that heat evolved during the hydratation of the latter may have contributed to this result.

Careful observations by Symons in a boring near London, at a depth of 1000 feet, extending over a period of eighteen months, show that the temperature at that depth, as might be expected, suffers no perceptible changes.

TERTIARY FORMATION OF THE ARCTIC REGIONS.

In connection with the discussion in the *Record* of last year (page cii), it may be noticed that Fr. Schmidt has summed up our knowledge of the Tertiary geology of the North. The Miocene there shows a great continental area characterized by coal-seams and by a rich fauna, and is traced from the Amoor basin into Kamtchatka, Alaska, Vancouver's Island, and eastward as far as Mackenzie River, Greenland, and Spitzbergen. The Pliocene was a marine deposit, and is not known in continental Siberia, but occurs in Sakhalin Island, in Kamtchatka, and the Aleutian Islands, and extends to Oregon and California. Of its fauna the greater number of species inhabit to-day the North Pacific, but some are found only in the Polar Sea and the North Atlantic. He concludes that the fauna of the two oceans was then more alike than at present, and that these were then more closely connected through the Polar Sea.

FOSSIL FLORAS.

Heer, from his studies of the fossil floras of Greenland and Spitzbergen, concludes that the facts are against a gradual transformation of plant-types, since, in the Upper Cretaceous, dicotyledons suddenly appear in great variety, while other forms at this period disappear as rapidly. He supports the view of an arctic origin and a southern migration of plants, and declares that his investigations of the northern fossil floras do not indicate any alterations of climate or former ice-periods in these regions. He thus confirms the conclusions of Nordenskjöld as stated in the *Record* for 1876 (page cii).

J. W. Dawson has extended this conclusion as to the arctic origin of the Tertiary floras to those of more ancient periods, and concludes that the Silurian, Devonian, and Carboniferous floras all entered the North American continent from the northeast, and that within the arctic circle was the great nursery in which the successive vegetations, from the oldest to the most recent, had their origin.

ANCIENT ARCTIC CLIMATE.

Dawson supposes that the subsequent change in climate in these northern regions was geographical rather than cosmical, and that the arctic climate *at the sea-level*, as long taught by the present writer, never attained the point of glaciation until the end of the Tertiary time.

In like manner, J. F. Campbell, abandoning his former views of a great ice-cap, now concludes that no geological record exists of any abnormal glacial periods colder than the world's climate of to-day. Geographical changes affecting the relations of sea and land, and elevating portions of the earth's surface into regions of the atmosphere where perpetual frost prevails, will, according to him, account for all the phenomena.

SUPPOSED DISPLACEMENT OF THE EARTH'S AXIS.

J. W. Dawson calls attention to the well-known fact that not only the movement of successive floras in this continent, but the directions of the great accumulations of sediment throughout all these periods, as well as the great lines of plication of the strata, which depend upon these, coincide with the direction of the polar currents of to-day, and remarks that all these facts go to refute the notion, which has lately been resuscitated, of a change in the position of the earth's axis of rotation—a view which, however conceivable to the astronomer and the physicist, cannot be admitted by the geologist, who sees, in the facts already set forth, the evidence that no considerable change of that kind can have taken place since the beginning of Paleozoic time. Polar currents seem to have been in all ages the potent agents in transporting the débris of older rocks towards the equator; while, on the other hand, as remarked by Dawson, the great organic limestones, which represent the contemporaneous food-bearing warm currents from equatorial regions, were deposited

in the plateaus and in the bays of the Eozoic and Paleozoic lands. See in this connection the same argument against a change of axis stated in the *Record* for 1876 (page cii).

AN ANCIENT ATLANTIC CONTINENT.

The results of soundings over the bed of the Atlantic have made clear the existence through the middle of the ocean, extending from north to south, of a sunken ridge, often less than 1000 fathoms from the surface, while on either side the water has a depth of from 3000 to more than 3450 fathoms; so that the elevation of the ocean's bottom required to make these depths dry land would bring up between them a mountain-range from 9000 to 15,000 feet in height. The higher points of this sunken ridge now form the islands of the Azores—St. Paul's, Ascension, and Tristan d'Acunha. This discovery was, in a manner, anticipated in 1860 by Unger, who, from his studies of the Tertiary flora of Europe and America, was led to imagine a land connecting the two regions, over which the plants of North America had passed eastward. This, he supposed, might be the vanished Atlantis of which Plato has preserved the tradition.

Other reasons have led geological observers to conclude that great areas of land existed in the Atlantic region in Paleozoic time; and the present writer, in 1872, urged the existence of a Paleozoic Atlantis, from the ruins of which had been derived the enormous volumes of material which make up the uncrystalline rocks of Eastern North America. The Paleozoic sediments of these regions, many miles in thickness, must, as Hall and H. D. Rogers long since pointed out, have been derived from the waste of great areas of elevated land lying to the eastward. Clarence King has recently brought forward this doctrine in a forcible manner, and has described Palæ-Atlantis as a land-area of continental magnitude, from which vast quantities of sediment were brought down by rivers and poured into the Palæ-American ocean, upon the subsiding bottom of which were built up the thick Paleozoic formations which stretch throughout Eastern North America. He also claims the existence of a corresponding Pacific continental area, which he names Palæ-Pacifis. The lower Paleozoic rocks of Great Britain, when compared with those of Scandinavia and Russia, show a diminution in thickness in

going eastward not less remarkable than that observed in the opposite direction in the strata of the same age in North America.

EUROPE AND ASIA IN THE GLACIAL PERIOD.

Belt has put forward a theory with regard to the glacial period in Northern Europe. He supposes, with Croll, that the North Sea between Scandinavia and Scotland was at one time filled with ice, so that (Great Britain being then continuous with the continent) the German Ocean was blocked up to the north, and formed a great lake, the waters of which found an outlet to the southwest, and gradually cut through the Straits of Dover. From the waters of this lake, which gradually became fresh, were deposited the clays of Southeastern England. The ice, as it advanced southward, reached the coast of Norfolk, and not only denuded and disturbed these clays, but, according to Belt, uplifted both the Cretaceous and Neocomian, and even forced the boulder-clay beneath their inclined strata.

THE LOESS OF CENTRAL EUROPE.

The alluvial deposit known as the loess, which attains a height of 900 feet above the sea on the Rhine and 1300 feet on the Danube, is, in the opinion of Belt, of glacial origin, and, in fact, the equivalent of the northern glacial drift, which passes gradually into the loess. The conditions which permitted the deposition of these were, according to Belt, brought about, not by a subsidence of the land, but by a great glacier which occupied the bed of the Atlantic to a height of about 1700 feet above the sea, damming back the rivers which drain the continent, and converting this into a vast lake, which was filled with icebergs. He has since extended this hypothesis, and supposes that another great glacier extended down the North Pacific, arresting also the drainage of Asia.

After the Miocene age, the Aralo-Caspian area was cut off from its connection with the Mediterranean, when the northern basin grew fresh, and discharged its waters to the north, until, by the accumulation of ice both in the Atlantic and the Pacific, the drainage of this region was checked, and there was formed a great lake, into which came the icebergs

from the north, depositing boulder-drift in the north and clay in the south of Russia. This state of things was finally put an end to by the cutting of the channel of the Bosphorus, through which the waters found an exit-southward.

GLACIAL PHENOMENA AROUND LAKE ONTARIO.

George J. Hinde has studied the Post-tertiary deposits near Toronto, which throw new light on the geology of that region. The eroded Loraine or Cincinnati shales are here overlaid by a considerable thickness of boulder-clay, including a veritable pavement of striated boulders. Overlying this are thinly stratified sands and clays, which have a maximum thickness of 140 feet, and contain remains of plants, chiefly mosses, with some mollusks and crustacea, showing this to have been a lacustrine deposit. These are conformably overlaid by about forty feet of sand. Subsequent erosion has cut in one case a valley in these stratified deposits to a depth of more than one hundred feet, and the clay beds in the vicinity of the erosion are often curiously contorted. Over this is a second boulder-clay, filling up the depressions, and covering over the higher portions to a depth of seventy feet. This is, in its turn, overlaid by a second series of stratified clays without observed organic remains, upon which appears in one place a stratum of about thirty feet of what is regarded as a third deposit of boulder-clay, succeeded by stratified sands and gravels.

To correlate these deposits, studied by Mr. Hinde, with the clays of the regions farther south and west will require further study. The evidence of more than one period of erosion was many years since pointed out by the present writer, who showed the existence of a vast rock-basin cut out of the Devonian strata, and filled up with clays, out of which latter deposit the basin of Lake St. Clair and that of the southwestern half of Lake Erie were subsequently eroded, the stratified clays on the shores of the latter reaching to depths far below the bottom of the lake.

GLACIAL PHENOMENA IN LABRADOR.

Henry Youle Hind has studied the joint action on the Labrador coast of the polar current and of the sheets of ice called by the fishermen pans (*i. e.*, panes). These are great

tables or plates, varying from five to ten and twelve feet in thickness, and from a few square yards to many acres in extent, which are formed by the breaking-up of the coast and bay-ice in the month of June. These sheets, when pressed to the coast by winds and urged by the unfailing arctic current from the northwest, rise over the low-lying shores and islands, removing every obstacle in their way, grinding and polishing the surface, and rounding into boulders the masses broken or torn from the cleavable rocks in their course. This process, with some interruption from winds, goes on for a month or six weeks every year, and the bottom of the sea, to the depth of twelve feet or more, exhibits white smooth surfaces, which have been thus ground and planed by the action.

Pan-ice, according to this observer, is now "exerting an abrading action over a vast coastal and submarine area throughout the shallow seas that fringe Labrador. In a word, it is doing before our eyes, over a coast-line many hundred miles in length, what has been done in earlier times over a vast area of the North American continent, according as fresh surfaces, by a rise or subsidence of the land, were brought under the influence of pan-ice aided by an arctic current. The evidence of a gradual uplifting of this coast during the continuation of this process is seen in the smooth worn surfaces up to more than 600 feet above the present sea-level. The material pushed to and fro along a shallow sea-bottom by this action of ice must accumulate in submarine depressions in the form of boulder-clay, which, however, in a rising area, would, except where locally protected in deep valleys, be remodelled by the action of the waves." To such an action he attributes the boulder-clays of Nova Scotia.

Similar views of the action of shore-ice are urged by J. Milne, who, from his studies in Newfoundland and Labrador, as well as in Finland, concludes that many of the phenomena which some have referred to the action of an ice-cap, or a great extension of land-ice, are due to the action of coast-ice on an oscillating and especially on a rising submarine area. On the other hand, the phenomena described on the shores of Lake Ontario are strongly urged, by its advocates, in favor of the hypothesis of subaerial glaciation.

HYDROGRAPHY.

By FRANCIS M. GREEN,
Lieutenant-Commander, U.S.N.

During the past year a large amount of work has been performed by hydrographic surveyors in different parts of the world, both in actual surveys and in preparing and publishing the results; although the record of the year's work does not show any one great task either commenced or brought to a conclusion.

As heretofore, the English have accomplished more than any other nation, but American, French, German, Russian, Austrian, and Italian naval officers have also been steadily working to increase and perfect the knowledge of the shores and depths of the ocean.

Owing to the very limited appropriations of money for the maintenance of all branches of the United States government for the past year, the operations of the United States Hydrographic Office and the United States Coast Survey have been very limited.

For this reason no surveys of any consequence have been carried on by the Hydrographic Office.

Forty-one new charts of various parts of the earth's surface have, however, been compiled and published for the use of navigators; sailing directions for the coasts of the Mediterranean Sea, the west coast of Africa, and the West Indies have been prepared and issued; and a very large number of notices of changes in the channels of navigation and of alterations in lights, buoys, and other aids to navigation have been published.

A careful examination of the singular bank discovered by Lieut.-Commander Gorringe, U.S.N., off Cape St. Vincent, has shown that the least depth on it is about thirty fathoms, so that it need not be feared as a danger to navigators.

The late Commander Ryan, in the U.S.S. *Huron*, carefully determined the latitude and longitude of about twenty

points along the north shore of South America, besides gathering a large amount of valuable information regarding that coast, and, when lost with his ship, was proceeding to correct as many as possible of the discrepancies and errors known to exist in the charts of the island of Cuba.

Commander Schley, U.S.N., is engaged in the U.S.S. *Essex* in running a line of deep-sea soundings from Liberia, by way of St. Helena, to Rio de Janeiro, a work which will give an entirely new cross-section of the South Atlantic Ocean.

The work of determining by telegraph the differences of longitude between points in the West Indies and the United States having been completed, and the results published by the Hydrographic Office, the same officers of the United States Navy have commenced the measurement in the same way between Lisbon and Pernambuco, Rio de Janeiro, Monte Video, and Buenos Ayres, connecting at the latter point with the chain of longitudes measured by Dr. B. A. Gould from the Cordoba Observatory.

Under the superintendence of the United States Coast Survey the survey of the Gulf of Mexico is steadily progressing. Lieut.-Commander Sigsbee, U.S.N., in the steamer *Blake*, to whom this extensive work is confided, has during the past season run 6600 miles of soundings, with an average of one sounding for every six and three-tenths miles, and using for all depths over one hundred fathoms the wire sounding-machine devised by himself. Serial temperatures from surface to bottom were taken at two hundred and twenty-two localities, while surface and bottom temperatures were taken at many more. Large numbers of specimens of bottom have been obtained for examination, as well as numerous specimens of water from various depths.

During the coming season Lieut.-Commander Sigsbee will extend the survey to that part of the Florida stream between the Florida reefs and the coast of Cuba, and will be accompanied by Professor Alexander Agassiz.

On the Atlantic coast the Coast Survey have prosecuted hydrographic surveys on the coast of Maine, on the south side of Long Island and in Long Island Sound, in the Currituck, Albemarle, Pamlico, Core, and Bogue sounds, in the Florida channel, and in the Indian and St. Johns rivers, Florida.

In the Gulf of Mexico, in addition to the deep-sea work performed by Lieut.-Commander Sigsbee, surveys have been prosecuted on the west coast of Florida, near Cedar Keys, and between St. Andrews and Pensacola, on the coast of Louisiana and in the Mississippi River. At the mouths of the Mississippi observations for currents, volume of discharge, changes of depth, etc., have been continued.

On the Pacific coast work has progressed rapidly on the coasts of California, Oregon, and Washington Territory.

Off-shore tidal-current observations have been continued, and ten tide gauges on shore have been constantly observed and recorded, in addition to those operated by hydrographic parties.

The work of compiling the Coast Pilot for the Atlantic coast and for the coast of Alaska has made steady progress, while a large force in the office has been constantly employed in constructing charts from new surveys, and in the endless work of correcting older chart-plates in accordance with recently discovered changes.

An excellent *précis* of the work done by English Admiralty Surveyors is given in the *Nautical Magazine* for July, 1877.

The constant demand for more exact information regarding very many partially surveyed regions, in order to develop new channels of commerce, is very great and is constantly increasing, and the world is indebted to English surveyors for an immense amount of valuable work in this direction.

Owing to the sandy nature of the bottom at the mouths of several of the rivers and estuaries on the shores of Great Britain, it is necessary at frequent intervals to re-survey them.

In Yarmouth harbor, at the mouth of the river Thames, in the Solway Firth, at the mouth of the river Tay, and at the mouth of the river Shannon, marked changes were found during the past year to have taken place in the channels and shoals.

In the Mediterranean, Captain Wharton, R.N., in H.M.S. *Fawn*, has continued the examination of the mouth of the Nile and the entrance to the Suez Canal.

A considerable advance of the land is shown to have taken place at the Damietta mouth of the Nile, as compared with its condition in 1856. A careful examination of the depths

in the canal showed that the reports of its decrease in depth were without foundation.

Captain Wharton states that at the season of highest Nile, the water at the Damietta mouth is so charged with mud that it forms a sort of breakwater for the region to leeward of it, the wind being powerless to raise it into waves.

Passing into the Red Sea, Captain Wharton has done very valuable work in surveying an inshore route along the African coast, by which small vessels may avoid the stormy southerly winds and heavy sea prevalent during the summer months.

At Mauritius, Lieutenant Coghlan, R.N., has commenced a much-needed survey of the shores of that island, no hydrographic survey ever having been made.

In the China Sea, Commander Napier, in H. M. S. *Nassau*, has done a large amount of work in Carimata and Hai-tan straits, as well as in the labyrinth of shoals and channels in the Strait of Malacca.

On the coasts of Corea and Japan, Captain St. John, R.N., and the officers of H. M. S. *Sylvia*, have surveyed and connected the numerous groups of islands lying between Japan and the northern parts of China.

A party under command of Staff-Commander Maxwell have divided their labors between Placentia Bay and the northeast coast of Labrador, which work can only be done in midsummer.

Lieutenant Pullen, R.N., has energetically pushed the survey of the island of Jamaica.

The surveys of the shore of Australia have been carried on by four fully organized parties, and a large amount of work has been accomplished.

The general survey of the Fiji group under charge of Lieutenant Moore, R.N., has made marked progress.

A detailed survey of the Gettysburg bank discovered last year by Lieut.-Commander Gorringe, U.S.N., has been made by Commander Egerton, R.N., who, however, failed to find a less depth on it than had been found by its discoverer—viz., thirty fathoms.

Besides the direction of all these surveys, the British Hydrographic Office has published 167 notices to mariners, consisting of notifications of changes in lights, buoys, etc.; 350

pages of hydrographic notices; new editions of sailing directions for the Mediterranean; directions for the Dardanelles and Black Sea, the west coast of Scotland, and the "Australia Directory;" 62 new charts have been published, 1896 have been corrected, and 180,000 have been printed and disposed of for the use of navigators.

Under the direction of the Indian Government, English naval officers have also been busily at work on the surveys of the coasts of India and Burmah, extending the incompleted charts of the coast, and re-surveying those ports and harbors in which natural and artificial changes are constantly being effected.

Under the direction of the French Ministry of Marine, extended surveys have been made on the coasts of France, especially of the approaches to the ports of Boulogne, Rochelle, and St. Jean de Luz, to determine the changes in depth and position of the various channels.

In the Gulf of Siam, French surveyors are busily at work in exploring and surveying; here, as elsewhere, increased commerce being accompanied by an urgent need of exact knowledge of the shores.

Detailed charts will soon be published of the recently completed surveys by MM. Herand and Bouillet in 1873–4–5 of the delta of Tong-kin.

Charts of the coasts of Tunis and Tripoli from the survey recently completed by Captain Mouchez are in course of preparation, and will be shortly published on a scale of $\frac{1}{50000}$.

In addition to these surveys, the French Dépôt de la Marine has continued, as heretofore, the publication of corrected charts and nautical books. Eighty-two charts have been published of various parts of the globe, and a number of most valuable nautical books, including the "Annales Hydrographiques," issued quarterly; the "Livret des Phares;" "Récherches Chronométriques;" sailing directions for the north coast of France, for New Caledonia, and for the mainland of America from Guiana along the shores of the Caribbean Sea and Gulf of Mexico to the south point of Florida.

Under the auspices of the Imperial German Hydrographic Office, a re-survey of the shores of the German Empire has been commenced.

In the Baltic Sea the hydrographic portion of this work is

being carried on under the direction of Captain Hoffmann, H. M. S. *Dolphin*, and in the Baltic by Capt.-Lieutenant Holzhauer, H. M. S. *Drache*, who are working in unison with the triangulating and topographic parties on shore.

As might have been expected, this great undertaking is being carried on with all possible accuracy and minuteness.

The publication of the *Annalen der Hydrographie*, containing many valuable reports of the commanders of German men-of-war in foreign waters on hydrographic matters, has been continued.

Sailing directions for the coasts of the Skagerrack, the Cattegat, and the Belts are in course of publication, and are being carefully compiled for the whole German coast.

The work of the Norwegian Exploring Expedition in the North Atlantic, under direction of Professor Mohn and Captain Wille, has been steadily prosecuted.

The results of the soundings with the temperature and current observations of last year, including all the soundings taken between Iceland, Greenland, and the British Isles since 1860 by British, German, and Norwegian vessels, are given in a chart by Professor Mohn, physicist to the expedition (*Nature*, Oct. 18, 1877). This chart shows isobathal curves at intervals of 100 fathoms, giving a detailed representation of the configuration of the sea-bottom.

This year the expedition left Tromsö July 24, returning August 23. Sounding and dredging were effected between the Lofoden Islands and Jan Mayen, a careful survey of the latter island being made.

The boundary between the polar current and the warm Atlantic current was found to be very steep, like that called the "cold wall" on the American coast. Next year the expedition will work up the region between North Cape, Jan Mayen, and the north of Spitzbergen.

In a paper in the May (1877) number of Petermann's *Mittheilungen*, Dr. Dorst furnishes a valuable addition to the knowledge of currents of the region between Greenland and Spitzbergen, by a discussion of the movements of the ice as observed by him in 1869.

Dr. Petermann has been furnished by Captain David Gray with a large amount of material for the determination of mean surface temperature of the Greenland and Norwegian

Sea, 1800 measurements having been made during six summer voyages between 58° and 81° N. latitude.

Much attention has been given to the subject of water communication between Western Europe and the rich country near the mouths of the rivers Obi and Yenisei, in Siberia.

The Swedish expedition under Professor Nordenskjöld; the expedition from Bremen under Dr. Finsch and his associates, as well as Captain Wiggins, F.R.G.S., who made two exploring voyages thither in 1874 and 1876, are unanimously of the opinion that, during a portion of each year, suitable steamers may approach and leave this region with only the ordinary risks of navigation.

Earnest attempts are being made to turn this route to account. During the past summer, the steamer *Frazer*, loaded with tobacco, sugar, and machinery, has been despatched from Bremen for the Yenisei, under command of Captain Dallman, an antarctic explorer of experience; and the steamer *Louise* proceeded from London to the mouth of the Obi, and thence up that river and the Irtish to Tobolsk—over a thousand miles by river.

At Tromsö the Russian Government has caused to be fitted out several sailing vessels, which, with a tug, are to convey a number of Samoyede families, with building material, clothing, and provisions, to Nova Zembla, to establish a colony there, which in time may serve as a useful half-way station on the route to the Obi and Yenisei.

The expedition of Captain Wiggins, F. R. G. S., to the mouth of these two great rivers surveyed, in the late summer of 1876, Poderata inlet, in which a good harbor was found, and discovered a large harbor at the mouth of the Obi. The Obi River was not entered.

The temperature of both air and water was singularly warm, though the Sea of Kara was full of ice. Captain Wiggins reached Kureika, on the Yenisei, in October, and there left his vessel and returned to England, having found, so far, excellent navigation. He started again in March, 1877, for Kureika, purposing to cross the Sea of Kara during the summer; but, on rejoining his vessel, the crew refused to proceed in her.

The results of all these expeditions are so encouraging that the Russian Government proposes to make immediate-

ly an accurate hydrographic survey of the Obi and the Yenisei.

This new trade route, if the anticipations be borne out by experience, will be of immense value, the region abounding in fish and furs as well as in agricultural and mineral wealth, while the population need great quantities of the productions of Western Europe, heretofore carried overland.

In the *Geographische Blätter* of the Bremen Geographical Society, a sketch of Professor Nordenskjöld's proposed voyage to the Siberian seas is given.

He intends to sail in July, 1878, in the steamer *Vega*, commanded by Captain Palander, a Swedish officer of much arctic experience, with a staff of three or four scientific observers, and a crew of thirty naval seamen. The object of the expedition is to force a passage from Nova Zembla eastward along the coast of Siberia through Behring Strait, the ship proceeding homewards through the Suez Canal. The cost of the expedition will be defrayed principally by the Swedish Government.

A review of the work done during the last twenty years, in determining the depths of the ocean in various parts of the world, is given in Petermann's *Mittheilungen* for April 1, 1877; special attention being paid to the depths determined in the Pacific Ocean, of which a small chart is given, showing the various deep basins, to thirteen of which Dr. Petermann has given the names of the ships, commanders of expeditions, and eminent scientific men who have been instrumental in the work.

A very marked feature of this chart is the uniform northwest and southeast direction of the elevations of the bottom surrounding groups of islands, etc.

GEOGRAPHY.

(Exclusive of North America.)

By FRANCIS M. GREEN,

LIEUTENANT-COMMANDER, U.S.N.

The past year shows no diminution in the general interest felt all over the civilized world in the development of exact and scientific knowledge of the earth's surface. The most marked discovery which has taken place has been that of the course of the Congo and Lualaba rivers by Mr. H. M. Stanley.

Governments are freely extending protection and assistance to explorers seeking to open new commercial routes; and the faithful and scientific spirit in which explorations are now conducted is shown by the care taken to attach experts in all branches of natural history to every expedition.

The scientific results of the English Arctic Expedition, and of the voyages of the *Challenger* and *Gazelle*, are being prepared for publication with great care.

The most important geographical work in course of publication is Viviers de St.-Martin's "Dictionnaire de Géographie Universelle" and his "Atlas Universel de Géographie, Ancienne, Moderne, et Moyen-âge," both issued in numbers, the publication of the first to run through four years and the second twelve and a half years.

Among the proofs of the interest now taken in geographical studies may be mentioned the founding of several new German, French, and Italian magazines and journals, specially devoted to the record of current travel and exploration, and the largely increased circulation of geographical periodicals previously established.

From these publications, especially the *Geographical Magazine*, Petermann's *Mittheilungen*, and *Cosmos*, a large portion of the following summary has been compiled.

In Petermann's *Mittheilungen* is given a review of the cartography at the Centennial Exposition. From the fact that maps and plans were shown in the departments of their

respective countries, it was difficult to compare the different exhibits effectively.

The general conclusion reached is that, as regards every nation, great progress has been made in cartography over earlier exhibitions; that, in respect to accuracy and clearness, the Germanic nations excel. Sweden surpasses all in minuteness of detail, England in clearness and delicacy of outline, and the United States in the art of turning to account material for statistics.

COSTA RICA.

The results of Professor W. M. Gabb's labors in Costa Rica in 1873–4 have been published by Dr. Petermann in map form. As yet the province of Talamanca only, constituting the southeastern portion of the republic, has been surveyed, the tracts lying to the west and north being still unexplored.

ISTHMUS OF DARIEN.

The general results arrived at by the French Surveying Expedition, under the command of Lieutenant Wyse, have been published.

The object was to find a route for a canal to join the Atlantic and Pacific oceans without locks or tunnels; but this desideratum does not seem to have been accomplished.

The route examined was along the course of the Poyita and Cacarica rivers; but the lowest practicable pass over the Cordilleras was found to be 450 feet above the lowest tides.

M. Celler, one of the engineers of the party, proposes a canal 65 miles long, by way of the Atrato and Tuyra rivers, with reservoirs and groups of locks.

Lieutenant Wyse is engaged in fresh investigations in this region on behalf of the Comité du Canal Interocéanique.

COLOMBIA AND ECUADOR.

The results of the journey by M. Édouard André through Colombia and Ecuador in 1875 and 1876 are of great value.

M. André has secured many valuable specimens of natural history, as well as an archæological and ethnographical collection, besides having measured many heights, taken careful latitude and longitude observations, and obtained numerous sketches and photographic views of the country.

GUYANA.

The valuable results obtained from recent explorations of the remoter regions of English and Dutch Guyana have incited the French authorities to despatch an exploring expedition, under direction of Dr. Creavaux, to ascend the Maroni River, returning by way of the Oyapoc or the Amazon.

BRAZIL.

The Department of Topography of the Brazilian Government has lately issued a map of the Madeira and Purus rivers, which throws some light upon one of the most obscure portions of South American hydrography, the river system of the province of Beni.

A recent work on Brazil, by Mr. Oscar Canstall, contains a popular description of the country, its geography, flora, fauna, political and commercial relations, etc.

BOLIVIA.

The late Professor James Orton, who died on Lake Titicaca, September 25, 1877, while on his return home, has been exploring the head-waters of the Madeira and Beni. From La Paz he had travelled, by way of Cochabamba, to the head of navigation on the river Chimoré, which he descended by canoe to Trinidad.

This is the first expedition down this river, Lieutenant Gibbon, U.S.N., having explored the Chaporé and D'Orbigny the Securé.

Professor Orton has contributed greatly to our knowledge of the head-waters of the Amazon, this being his third expedition to that region, the first one being made in 1867, crossing the Andes eastward from Peru, and descending the Napo to the Marañon.

His second expedition in 1873 was the reverse of the former one, beginning with the ascent of the Amazon.

The great work of Dr. Reiss on the "Andes Lands of South America," prepared in conjunction with Dr. Stübel, will soon be ready.

In the proceedings of the Royal Geographical Society for Nov. 26, 1877, is an important paper on Bolivia, by Commander Musters, R.N., who has lived there for many years.

Mr. Minchin, C.E., while surveying for a railroad between La Paz and Lake Titicaca, has determined the heights with great care.

His results are: Lake Titicaca, 12,545 feet above the sea-level; Alto de La Paz, 13,389 feet; Plaza Mayor de La Paz, 11,946 feet; Summit of Mount Illimani, 21,224 feet.

PERU.

A new geographical society has been established at Lima.

Towards the end of last year, a commission, directed by Major D. A. Rivera and Mr. A. Werthemann, an engineer in the Peruvian service, was engaged in exploring the rivers Perené and Tambo, tributaries of the Ucayali, to ascertain if navigable communication were possible between the Perené and the Amazon at Iquitos. It is intended to extend the railway between Lima and Oroya, so as to form a highway of railway and navigable river across the continent from the Pacific to the Atlantic.

An account of this survey has been recently published at Lima, and forms a valuable contribution to Peruvian geography. Mr. Werthemann states that a length of only forty-eight miles of railway would be required to unite the European settlements of the Chancamay and Pancartambo valleys with the highest navigable point of the Perené.

He estimates that a route, passing from Lima by land through Oroya, Palca, Tarma, and Paucartambo, and by river along the Perené, Ucayali, and Marañon to Iquitos, could be traversed in twelve days; and that, if the railway were extended to the Ene, the time of transit from the Pacific coast to the main Amazon could be reduced to eight days.

The second volume of Señor Raimundi's work on Peru contains the geographical history of the country from the Spanish conquest to 1800. More recent geographical progress will be noticed in the third volume.

Mr. E. G. Squier's "Incidents of Travel and Exploration in the Land of the Incas" has recently been published, and adds much to previous knowledge.

PATAGONIA.

Don Francisco Moreno has made a journey up the Santa Cruz River on the east coast of Patagonia, which he has described in a letter to the *Buenos Ayres Standard* of May 13, 1877.

He describes the Santa Cruz as issuing from a fine lake of the same name, thirty miles long and ten miles wide, in latitude 50° 14′ S. and longitude 71° 59′ W. The current of the river runs very rapidly, so that thirty days were occupied in ascending it.

Señor Moreno was the first to explore Lake Santa Cruz, on the shores of which he made a large geological collection.

Connected with the Santa Cruz Lake by a river 200 yards wide is Lake Biedma, in the immediate vicinity of Mount Chalten, a still active volcano.

ARCTIC REGIONS.

The Blue-book of the Nares Expedition, published during the past year by the English Government, contains Captain Nares's comprehensive report, with special maps and a large amount of most valuable matter for students.

In the pages of the *Geographical Magazine* for the past year has appeared, from time to time, an admirable review of the work accomplished by the Nares Expedition. That the *Alert* wintered farther north than explorers had ever before wintered; that three hundred miles of new coast-line were discovered and surveyed; that one party reached the most northerly point ever attained; that the duties of everybody, from the leader downward, were conscientiously and thoroughly performed, and that the whole work was conducted with eminent ability and sound judgment, giving invaluable results, has been thoroughly demonstrated.

The official narrative of the Polaris Expedition, edited by the late Rear-Admiral Davis, and published by the U. S. Navy Department, will prove a valuable record for reference.

The first volume of the physical results of the same expedition, by Dr. Emil Bessels, has also been published under the auspices of the Smithsonian Institution.

The Austrian scheme for the establishment of stations of observation within the arctic circle has again been brought

forward, and seems likely to be carried out. Lieutenant Weyprecht, who commanded the Austrian expedition that discovered Franz-Josef Land in 1874, and Count Wilczek, one of the promoters of that expedition, have announced that they intend to undertake an arctic expedition to establish a station of observation in Northern Nova Zembla, and they strongly urge the establishment of others at various points both in the northern and southern hemispheres.

GREENLAND.

No more valuable contribution to geographical literature has appeared for a very long time than Dr. Rink's "Danish Greenland." For sixteen winters and twenty-two summers the author resided in the country, for a portion of the time as its governor. Not only could no other living person have written this book, but its accuracy and completeness appear to be beyond criticism.

EUROPE.

The great demand of the year has been for maps and descriptions of the seat of war—a want partly supplied by the reissue of old maps, and partly by the publication of numerous new ones, as nearly accurate as could be expected of countries not having the advantages of a systematic government survey.

Among the best of new issues is a map of European Turkey, in seventeen sheets, on a scale of $\frac{1}{420000}$, by Colonel Artamanow, of the Russian service.

The steadily increasing interest in exact geographical knowledge is attested by the increasing membership of the older geographical societies, and the establishment of new ones at Copenhagen, Antwerp, Brussels, Marseilles, and Bremen.

In Germany the Imperial Railroad Commission has published a chart of the most extensive net-work of railroads in the world; and a complete physico-statistical atlas of Germany has been edited by Messrs. R. André and O. Peschel.

A complete catalogue of dwelling-places in the kingdom of Bavaria, and a new topographical map of Baden, deserve mention.

The project of draining the southern part of the Zuyder-

Zee has been submitted by the government of the kingdom of Holland to the States-General.

Count Bela-Szechenyi's "History of Neusidler" Lake gives a curious account of the rise and fall of its waters, with the reasons for the phenomena, and interesting discoveries from the stone age in the lake. In 1854 the waters of the lake, which lies in the western part of Hungary, near the Austrian frontier, began gradually to sink, until in 1868 there was not left so much as a marshy spot in its bed; but since 1869, they have been slowly returning, until in 1876 the surface of the lake has resumed its normal appearance.

The second division of "La France" has been completed in the admirable work of Élisée Reclus, "Nouvelle Géographie Universelle."

PALESTINE.

The scientific survey of Western Palestine, under the charge of Lieutenant Kitchiner, R.E., has been completed. This laborious undertaking has been pursued, in spite of many difficulties, for more than five years, and it now only remains to work out the map of Palestine, which will consist of twenty-six sheets, on the scale of one inch to the mile.

A report on the "Line of Levels from the Mediterranean to the Sea of Galilee," by Lieutenant Kitchiner, has been read before the Royal Geographical Society.

The levels extended over about thirty-six miles, and the result of the work showed the depression of the Sea of Galilee to be 682.5 feet below the Mediterranean, being 40 or 50 feet greater than had been generally supposed. The depression of the Dead Sea was found to be 1292 feet, and that of the deepest part of the valley of the Jordan 1300 feet below the Mediterranean. There seems no doubt that the whole of the enormous quantity of water brought down by the Jordan to the Dead Sea is carried off by evaporation.

A German association for the exploration of Palestine has been lately formed by scientific men, in different parts of the empire and in Switzerland, the headquarters of which will be at Baedeker's in Leipzig.

ASIA.

Under the auspices and direction of the Russian Geographical Society, various journeys and explorations have been carried on in Siberia and in Central Asia.

A most important work has been the carrying of a line of levels along the Siberian road from Ekaterinburg to Irkutsk, a distance of 2236 miles, by which the exact heights of numerous important meteorological stations have been established. With the aid of the knowledge thus derived, it will no longer be impossible to trace isobaric curves over this region.

The determining of the precise differences of longitude by electric time-signals along the line of telegraph extending from Moscow to Vladivostock, now completed, is a work of immense importance, upon the results of which the geographical positions of points in Japan and China will hereafter depend.

Under the direction of the Siberian branch of the Russian Geographical Society, a careful exploration of Lake Baikal and the surrounding country has been carried on. Besides the regular bulletin of the society, containing a great amount of valuable material, the other publications of travels and explorations by members of the society afford abundant testimony to the zeal and ability which are constantly adding to the geographical knowledge of Russian territory.

The geographical results of Colonel Przewalski's expedition into Chinese Tartary, during the past year, are a survey from Kuldja for eight hundred miles into the interior of the country, seven determinations of latitudes and longitudes, many hypsometric measurements, and large botanical and zoological collections. He arrived at Lob Nor, as stated in the *Record* of last year, on February 11, travelling by the way of the valley of the Lower Tarim.

The height of the valley above the sea is about 2000 feet, and its topography is quite different from that represented on the maps, the survey and the astronomical determination of latitudes and longitudes giving quite a new aspect to the country.

He found the country on the banks of the Tarim and about Lob Nor very thinly settled—the people speaking

almost the same language as in Eastern Turkestan. He found Lake Lob Nor to be an enormous marsh, surrounded and partly overgrown by thick bushes.

About one hundred and twenty miles south of Lob Nor, Colonel Przewalski encountered a range of mountains more than 11,000 feet in height, called the Altyn-Tag, and appearing to be the spurs of a more important range.

The expedition started for Thibet in August last.

With great difficulty and danger, Captain Kurapatkin, another Russian explorer, has completed a journey in Kashgaria (between July, 1876, and April, 1877), the details of which have been communicated to the Paris Geographical Society.

M. Potanin is engaged, under the auspices of the Russian Government and the Russian Geographical Society, in a survey of Northwestern Mongolia, a work which was intended to last two years, dating from the summer of 1876. As, however, some trouble was experienced from Chinese authorities, he did not begin his task till April, 1877.

The reports of the Russian military expedition to the Alai and Pamir plateaux, by Colonel Kostenko, add very materially to the knowledge of the mountain chains of Central Asia, differing, however, essentially from the accounts recently published by Captain Trotter, R.E.

Colonel Stubendorff is preparing a map of the expedition; Usbel Pass, 14,400 feet above the sea, being the highest point indicated.

A treatise by M. Musscheketow on the volcanoes of Central Asia is of very general interest. Since his discovery of burning coal-layers in the basin of the Ili, he has been convinced that the volcanoes indicated by Humboldt in that and neighboring regions are simply such burning coal districts.

Although referring to the recent action of some extinct volcanoes, he altogether doubts the existence of true volcanoes in Central Asia, and adduces a large mass of evidence in support of this position.

While in command of a detachment of Cossacks protecting a caravan, sent by Russian merchants, Captain Pevtsow made observations which afforded the following results: A survey of the route, 560 miles long, from the Zaisan Lake to

the Chinese town Gu-chen, latitude 43° 50′ N., longitude 90° 14′ E., with maps of the towns, astronomical determinations of the positions of seven points, magnetic observations, barometric measurement of heights, a complete geographical exploration along the route, a collection of about one thousand species of plants and a large zoological collection.

The first volume of Baron von Richthofen's extensive work on China has been published. This volume of 760 pages treats principally of the geography of Central Asia and China proper, entering thoroughly into the formation of the surface, and other features of physical geography. The work, when completed, will be accompanied by an atlas of forty-four maps, constructed by the author, chiefly from Chinese sources.

Mr. James Morrison has commenced the publication in the *Geographical Magazine* of a large amount of geographical information regarding the almost unknown island of Formosa—the results of journeys there during the past year.

AFRICA.

The most important as well as the most interesting event relating to African geography during the past year has been the exploration of the Lualaba River by Mr. H. M. Stanley, and his demonstration of its identity with the Congo.

It is too soon to give any exact account of his discoveries, but his journey may be summarized in a few words, as follows: At the close of last year's *Record*, Stanley, with his party, was at Nyangwe, lying about four hundred miles west of Lake Tanganyika, and hitherto the western limit of exploration. Leaving there November 5, 1876 (after an exploration of Lake Tanganyika, with its creeks and inlets, occupying fifty-one days), they started to the westward; but, unable to make headway through the thick forests, crossed the Lualaba and continued their journey along the left bank. The tribes of savage cannibals offered a most determined opposition to their passage, both by land and water; and in the midst of their desperate struggle with the negroes, after having taken to their canoes to drift down the river, they came to a series of five cataracts, not far apart, south and north of the equator. With great hardship and suffering, the boats were dragged through the forest for thirteen

miles around these cataracts. Besides these falls, numerous rapids and lesser falls were met with, in passing which, as well as in battles with the natives, many of Stanley's followers lost their lives.

Mr. Stanley reports that in 2° N. latitude the river Lualaba changes its previous northerly course to northwest, then to west, then to southwest—a broad stream from two to ten miles wide, and studded with numerous islands.

In all, the expedition was obliged to fight thirty-two desperate battles in forcing its way down the Lualaba, although some friendly tribes were met with. As the river approaches the Atlantic it is known as the Kwango and the Zaire. It has an uninterrupted course of over fourteen hundred miles through the great basin lying between 9° and 26° of E. longitude, and has many magnificent affluents, especially on the southern side. Between this great basin and the Atlantic Ocean is a broad belt of mountains, after passing which the river descends by about thirty falls and furious rapids, then forming the stream heretofore known as the Congo.

On the 10th of August, 1877, the party, diminished and exhausted, reached Embomma, on the Congo, a short distance from the mouth; and shortly afterwards arrived at the Portuguese settlement of St. Paul de Loando.

Mr. Stanley's discoveries are discussed by Dr. Petermann in the *Mittheilungen* for December, 1877.

The English missionary stations on lakes Tanganyika and Ukerewe afford most valuable starting-points and bases of operation for scientific travellers, as has been proved by the experience of Lieutenant Young at Livingstonia, the station on Lake Nyassa. Parties from these stations are penetrating the country in various directions, and making scientific observations.

The new Geographical Society of Lisbon has awakened great interest in Portugal regarding her African colonies, too long given up to an ignorant and unworthy class of half-breeds, who have prevented any real progress and have fostered an illegal slave-trade. The government has lately made a large appropriation towards a scientific exploration and survey of the region between Angola and Mozambique, to investigate the connections between the river systems of the Congo and Zambesi.

A railroad is to be built from Loando to Ambaca, and from Delagoa Bay to the Transvaal Republic.

The International Commission for the Exploration and Civilization of Central Africa, set on foot by the King of Belgium, has established national committees in Belgium, Germany, Austria, Holland, Spain, Italy, France, Russia, Switzerland, and Portugal. The pioneers of this society, consisting of two Belgian officers, Captains Crespel and Cambier, and a naturalist, Dr. Maes, sailed on the 18th of October for Port Natal, whence they will make their way to Lake Tanganyika, where measures will be taken to ascertain whether it be possible to found a station on the shores of the lake, or, leaving a depot there, the station be fixed at Nyangwe and Manyuema. The place to be decided upon is to be used as a basis for further exploration, and agriculture will be carried on to make the expedition self-supporting. The society is amply provided with funds, and proposes to set on foot two large expeditions to penetrate from Loando and Zanzibar at the same time. There is every prospect that this united effort will succeed in solving some of the problems connected with the geography of Central Africa.

The Italian committee for the exploration of Africa held its first session at Turin in June, when it was decided to co-operate vigorously with the International Society. For the present the energies of the Italian committee will be devoted to the maintenance of a supply station at Shoa, regarding this as one of the most favorable stations from which to send out expeditions for the exploration of the interior.

In the proceedings of the Royal Geographical Society for June 11, 1877, is an account, by Bishop Crowther, of journeys up the Niger River between 1841 and 1871, and notes on the neighboring countries. The delta of the river, he states, is enormously large, extending along a coast line of 120 miles, with a breadth of 150 miles in some places.

As the Church Missionary Society has resolved to send out a small steamer drawing only three feet, most interesting and valuable results may be expected from further exploration.

Bishop Crowther's intimate acquaintance with the numerous tribes inhabiting this region (no less than thirteen separate tribes, speaking as many languages, being met in a jour-

ney of seven hundred miles) makes his accounts of them unusually valuable.

At a recent meeting of the Berlin Geographical Society a report of Dr. Von Bary was read regarding his investigation of the Tuareg region of the Western Sahara. His researches lead him to the belief that there is but little, if any, reason to believe that the Sahara Desert is the bed of an ancient sea.

The recent annexation by Great Britain of the South African territory known hitherto as the Transvaal Republic has drawn attention to the geography of that immensely valuable region, and has shown how very much remains to be done to perfect a knowledge of it. In the *Geographical Magazine* for February, 1877, as well as in the *Mittheilungen*, are excellent maps showing recent explorations.

Considerable attention has been attracted to Dr. E. Holub's travels in South Africa, and particularly to his exploration of the middle course of the Zambesi. During the past summer he has communicated to a newspaper called the *Diamond Field* (printed at Kimberley, in West Griqua Land) detailed accounts of his observations in that region. He entirely confirms the statements of Cameron and Young regarding the active participation of Portuguese merchants in the slave-trade of the interior.

Under the personal superintendence of Colonel Gordon, R.E., assisted by Lieutenants Watson and Chippendall, R.E., and by M. Gessi, a thorough survey of the Nile has been made, commencing at Khartoum and ending at a point about forty miles from the north end of the Victoria Nyanza, a distance of 1500 miles. From these surveys two maps have been prepared, on a scale of thirty-five miles to the inch.

M. Gessi has circumnavigated the Albert Lake, and finds it to be one hundred and forty-one miles from northeast to southwest, and from forty to sixty miles wide. He has proved beyond a doubt that the Nile descends from the Victoria Nyanza, enters the Albert Lake, and flows from it, at a point fourteen miles farther north, to Dufli, thus setting at rest the question of the direct connection of the great river with these two lakes.

AUSTRALIA.

Surveys have been made on the Stevenson River, in the south, and on the Daly River, in the north, the valley of the latter being described as a rich and grassy district. A northwestern expedition, under Mr. W. O. Hodgkinson, starting from Queensland, has explored the country from the Flinders and Concurry rivers to the frontiers of South Australia, following the course of the Diamantina River, and finding great areas of good pasture-land, with beautiful lakes, bounded on the west by a sandstone range named the Cairns Mountains. The Herbert River flows for a short distance through South Australia, but afterwards unites with one of the sources of the great Mulligan River flowing through Queensland. The expedition returned in October, 1876, to the falls of the Leichhardt.

An extension of Mr. Hodgkinson's work has been planned. The expedition was to start about the end of September from near the head-waters of the Gregory River, which empties into the Gulf of Carpentaria, pushing eastward to Tennant Creek, and along the telegraph line to the waters of the Daly; thence eastward to the Nicholson River, in this way twice crossing the broad strip of unknown land between the transcontinental telegraph line and the Gregory River.

The end in view in all these surveys is, in addition to the acquiring of exact knowledge of the geography, the discovery of new pasture-lands.

Mr. Alexander Forrest crossed the Hampton Plains, in West Australia, last year, hoping to find pasture-land, but his investigations established the fact that the interior of West Australia is all desert.

The Katharine River was explored in 1876 by Mr. G. R. McMinn, Chief Geographer of the Northern Territory. Mr. McMinn is convinced of the identity of the Daly and Katharine rivers.

To the southwest of the Katharine River worthless lowland plains were found covered with a growth of scrub and spinifex.

Mr. E. Giles's report of his return trip across West Australia last year, with a carefully executed map of his route, has been published by the government as a parliamentary paper.

NEW GUINEA.

In a recent number of the *Zeitschrift* of the Berlin Geographical Society is an interesting paper by Captain Von Schleinitz on the geographical observations in New Guinea, in New Britannia and Solomons Archipelago, made by the Prussian expedition in the *Gazelle.*

The exploration of New Guinea is going steadily forward, and the Australian colonists are discussing its annexation.

Signor d'Albertis, whose first exploration of the Fly River was so successful, has made a second visit to that river, and by means of it has penetrated to the centre of the island, reaching a point in 5° 30′ south latitude, 141° 30′ east longitude. He reports that the whole country is flat and marshy, the land nowhere rising more than two hundred and twenty-five feet. The natives resemble those of the eastern part of the island in appearance, manners, customs, etc, but differ widely from the blacks of the northwest. Bananas, taro, and tobacco are cultivated to a certain extent.

The vicinity of Port Moresby is described as a well-watered and fertile country.

In M. Cora's *Cosmos* are published the reports of M. Miklucho-Maklay and of Signor d'Albertis regarding their recent explorations.

In the *Proceedings* of the Royal Geographical Society is an account by the Rev. S. Macfarlane of a journey made by him along the southern coast of New Guinea in March, 1877. Two fine harbors were discovered, and several good anchorages along the coast. The natives were friendly and numerous. Mr. Macfarlane found many errors in the published charts.

During the last summer the Dutch expedition for the exploration of Sumatra has traversed the island from west to east, and explored a large tract of country lying to the north of Padang.

It is understood that this expedition is preliminary to settlement and occupation on a large scale, the annexation of this great island to the Dutch East India possessions having for some time been urgently pressed upon the authorities at Batavia.

GEOGRAPHY OF NORTH AMERICA.

By SAMUEL H. SCUDDER,
CAMBRIDGE, MASS.

The most important explorations of the year 1877 were the government surveys of the unsettled parts of the national domain. The oldest of these, the Geological and Geographical Survey of the Territories, under Dr. Hayden, completed its field work in Colorado in 1876; so that this new state, although perhaps the most diversified in our Union, enters upon life under the most propitious circumstances, its whole territory better mapped than perhaps any older state. In 1877 the survey passed northward into Wyoming and Idaho, taking in a tract of country between 107° and 112° W. long., extending from the Pacific Railway northward to the Yellowstone Park—an area of about 30,000 square miles. This field of operations, a preliminary survey of which was made in 1872, may be more easily conceived by stating that its southern border is equal to the distance from Boston to Philadelphia or Montreal. A geodetic party carried the primary triangulation over this entire region, measuring two base-lines—one near Rawlins, the other near Bear Lake—locating prominent peaks at intervals of from twenty to thirty miles, building upon them stone monuments for future recognition, and travelling at least five hundred miles. Thirty stations were occupied and eleven more used as primary points, and an average of eight angles were measured at each station occupied. At the close of the season, the triangulation was connected near Ogden with that of the Fortieth Parallel Survey.

This region was also divided into three sections, each of which was covered by a distinct party, fully equipped for topographical and geological work: two of these divided between them the southern portion, including all the less diversified desert region; while the third took the elevated district in the northwest, in the immediate vicinity of the Yellowstone Park.

The southeast, or Sweetwater division, as it was called, embraced an area of nearly 11,000 square miles, extending northward to 41° 45′ N. lat., and westward to 109° 30′ W. long. In working this area, one hundred and seventy-one principal topographical stations were occupied, besides twenty or more subsidiary stations; eighty or more stone monuments were erected. While many of these stations, owing to the extremely desolate and irreclaimable character of the country surveyed, will probably never be used as initial points for detailed surveys, there still remain many others, which will be of great value as starting-points for isolated pieces of rectilinear work, where fertile valleys and oases in the desert country are rapidly coming into demand by settlers. The most important of these fertile valleys lie in the mountainous region to the north, in the upper waters of tributaries of the Platte and Yellowstone; and into this district a rectilinear survey was pushed by measuring a guide-meridian from the railway north, and the establishment of base-lines within the region itself. The guide-meridian had to be measured over seventy-five miles of desert country, where water was extremely scarce. Owing to threatened danger from hostile Indians, who were known to be in the vicinity of the Big Horn Mountains, the party was obliged to leave in the northeast about eight hundred square miles of unexplored territory.

The southwest, or Green River division, was a rectangle of similar size to the last, but the surveying party extended its work a little beyond its western limits, so that 12,000 to 13,000 square miles were surveyed. This area contains a greater extent of hilly country, but none so elevated as that in the northern portion of the Sweetwater district; and in it nearly three hundred and fifty stations and locations were made, more than fifty of which were marked with stone monuments. The party found the Green River basin a broad, flat, almost unbroken expanse, covered mainly with sage-brush and scattered bunch-grass, but the bottom lands well grassed and wooded. In the broken country to the west, the more elevated portions were heavily timbered, the hilly parts grass-covered, and the valleys filled with good soil, easily irrigable.

The Teton division to the north extended to the borders

of the Yellowstone Park, between 109° and 112° W. long., covering an area of 13,500 square miles, mostly drained by the branches of the Shoshone, or Snake River, a tributary of the Columbia. This was familiar ground to the chief of the party, since he had already partially surveyed the region in 1872. In its western portion the party made thirty topographical stations in an area of about 10,000 square miles. Considerable timber was found, with a fair average of arable and grass land, and streams never dry. The eastern and northern portion is far more rugged and inaccessible than any other part of the country covered by this year's survey. It finds its culmination in the snow-covered Teton and Wind River Mountains, in the latter of which the highest elevation is Fremont's Peak, 13,700 feet high. A comparison of Fremont's account with the observations of the party shows, however, that he did not ascend this highest peak (now bearing his name), but a lower summit, whose altitude he estimated to be 13,570 feet. In one sense, Fremont's Peak may be considered the centre of the continent, since from its summit may be seen in close proximity the head-waters of streams which feed the Columbia, the Colorado, and the Missouri. While engaged in the exploration of this district, the party received notice from the military commander at Camp Brown, through Indian scouts, to leave the country, on account of the danger from hostile Indians. Nearly a month of valuable time was thus lost, abridging somewhat the results of the season's work. Notwithstanding the various difficulties encountered, the party surveyed an area of about 6000 square miles of the most rugged mountain country in the northwest, and made over one hundred barometrical observations. Throughout his district, Mr. Bechler personally observed 7340 horizontal and 5700 vertical angles; and as they were repeated backward and forward, and checked by good barometric readings, they must give satisfactory results concerning the altitude of that extremely mountainous country.

Each of these three topographical parties was accompanied by a geologist. In the desert region careful notes were taken of the grazing facilities, timber, and irrigability of the country. It was estimated that in the least favored region—that to the east—only five eighths was desert land, one fourth be-

ing mountainous, and therefore more or less timbered, and one eighth valuable land. At one point beds of coal of great extent were found. The limitless expanse of bunch-grass land affords, in some otherwise desert country, grazing to enormous herds of cattle. Some parts of the country are not so desolate. In the western portion of the Green River district, the valley of the Bear River, which doubles so curiously upon itself near the famous soda-springs of Idaho, already supports a thriving population. Along its banks and in the neighboring region are fine acres of farming land, grass-covered hills, broad and fertile valleys. Throughout the region, the party noticed that the season was much colder than that experienced at the same altitudes in Colorado. In the mountainous regions to the north, especially along the western flanks of the Wind River range, remains were noticed of huge ancient glaciers; and, considering the enormous amount of snow and ice that was observed at the beginning of August, the geologists deemed that the discovery of still existing glaciers in that range would not be surprising. Moraines covering many square miles, often a thousand feet in thickness, extend downward through narrow valleys, now containing rushing streams; and, from all appearances, cessation of glacial activity must have occurred within a comparatively recent time, for scarcely any vegetation has sprung up on the light glacial soil, and the morainal deposits themselves bear every mark of freshness.

In the comparatively level country lying wholly within the Territory of Wyoming, stretching from the Wind River and Sweetwater Mountains to the Uintas, and through the middle of which the Pacific Railroad winds its way, the geologists found little besides nearly horizontal Tertiary strata, such as occur along the line of the railway. The mountains west of Green River are composed mainly of Carboniferous limestones, but are flanked on either side by hills of Jurassic and Cretaceous age, with Tertiary beds resting on the tilted edges of the older rocks. Still farther west, the Bear River Mountains in Utah are composed of Silurian and Carboniferous rocks—limestones and quartzites. To the north of the abrupt bend in Bear River the lower grounds are covered with basalt flows, evidently originating from numerous craters still remaining in the vicinity. This outflow accounts

also for the abrupt bend of the Bear River, since at this point a basalt plain is the only divide between it and the Portneuf, which flows into the Snake, a tributary of the Columbia; into which also the Bear once emptied, but now, reversing its course, flows into Great Salt Lake.

To the north of this region and of the great basin of the Upper Green, or Colorado River, the geology as well as the topography is more complicated, the country being exceedingly broken, and volcanic and eroding agencies having been active, both in long-past and more recent times; but the studies of Messrs. St. John and Endlich, to whom these districts were assigned, have solved many perplexing points, and their evidence will probably determine the relations of the principal stratigraphical phenomena to the main mountain chains, and enable us to form decided opinions concerning the geological age of the mountains themselves.

In addition to these parties covering definite districts, a fifth, under Dr. White, who has succeeded the late Mr. Meek as paleontologist to the survey, was assigned a special duty —viz., to endeavor to correlate the scattered stratigraphical observations which have been made by different parties on either side of the Rocky Mountain chain and of the Uintas. With his party he therefore travelled in such directions as would enable him to examine the geological formations in their succession, so as to determine as far as possible the questions which have arisen concerning the limits of each, its correlation with the others, and to define its paleontological characteristics. Such a work must precede any rational classification of the different formations.

He first traversed in various directions the plains at the eastern base of the Rocky Mountains of Colorado between Cheyenne and Denver; he next crossed the mountains by way of Boulder Pass, the Middle and Egeria Parks, to the head-waters of the Yampa, and passed a short way down that stream. Crossing the divide between this river and the White, he followed the latter nearly to Utah, then turned northward and crossed the Green River at the southern base of the Uintas, making many détours on the way; skirted the whole length of the Uinta Mountains westward, turned them by twice crossing the Wahsatch Mountains, and then followed

their northern side back to Rawlins, on the Union Pacific Railroad.

By this survey he has been able, as he believes, to show the identity of the lignitic series of strata east of the Rocky Mountains, in Colorado, with the Fort Union group of the Upper Missouri River, and with the great Laramie group of the Green River basin. The relative age of these beds has been a matter of long dispute among geologists, but the investigations of this year have proved their complete equivalence by the discovery not merely of one or two doubtful species common to the strata at any one point, but by an identical molluscan fauna ranging through the whole series in each of these regions. He also finds the plains of demarcation between any of the Mesozoic and Cenozoic groups, from the Dakota or Lower Cretaceous to the Bridger or Higher Tertiary, inclusive, to be either indefinable or very obscure; showing that, whatever abrupt changes may have taken place elsewhere during that period, sedimentation was here probably continuous. While each of the groups of either series possesses its own peculiar paleontological characteristics, it is also true that certain species pass beyond the recognized boundaries of each within the series.

While this ends our account of the regular exploring parties attached to the survey, it does not complete its activities. Under its auspices several parties have been making special investigations in the field. To gain a general conception of the vegetation of the Rocky Mountain region, and of its relations to that of the rest of North America, Sir Joseph Hooker and Dr. Asa Gray examined many parts of Colorado, Wyoming, Utah, Nevada, and California, travelling in all some 9000 miles. The results of their studies will appear in detail through the publications of the survey; but they are already able to state that the vegetation of the middle latitudes of North America resolves itself into three principal meridional floras, far more diverse than those presented by any similar meridians in the Old World—being, in fact, so far as the trees, shrubs, and many genera of herbaceous plants are concerned, absolutely distinct. Each of them is subdivisible into three. The first region comprises the Atlantic slope and Mississippi valley, and is subdivisible into an Atlantic, a Mississippi, and an interposed mountain, or

Appalachian region, with a temperate and subalpine flora. The second embraces the Pacific slope, and is subdivisible into a very humid, cool, forest-clad Coast range; the great, hot, drier California valley, formed by the San Joachin and the Sacramento, flowing (the one north, the other south) into the bay of San Francisco; and the Sierra Nevada, with a temperate, subalpine, and alpine flora. The vegetation of the third, or Rocky Mountain region, comprising all the country lying between the two districts already mentioned, is subdivisible into a prairie flora, found principally along the eastern flanks of the Rocky Mountains proper; a desert or saline flora, covering the greater part of Nevada, Utah, and Arizona; and a Rocky Mountain proper flora, temperate, subalpine, and alpine. The Appalachians and the Rocky Mountains, therefore, severally divide the floras of their respective districts into separate east and west sections; while in the California district, a hot and dry valley effects a similar result by intervening between two parallel ranges of mountains. The difference between the Atlantic and Pacific floras is specifically and to a great extent generically absolute, not a pine, oak, maple, elm, plane, or birch of Eastern America extending to Western, and genera of thirty to fifty species being confined to each. The Rocky Mountain region, again, though abundantly distinct from both, has a few elements of the Eastern region, and still more of the Western.

Under the auspices of the same survey, Professor Joseph Leidy, of Philadelphia, made a careful examination of the country about Fort Bridger, Wy., and of the Salt Lake basin, to study in life the fresh-water rhizopods of that region, in preparation of a work for the survey upon the subject; and Messrs. S. H. Scudder and F. C. Bowditch, of Cambridge and Boston, travelled through much of Colorado and Wyoming, and a corner of Utah, making collections of recent insects; but especially in search of fossil insects, which were known to occur at various distant points in the Rocky Mountain region. Travelling most of the time, they made their longest halts at Green River, Wy., and at Florissant, near Manitou, Col., in both of which places fossil insects are abundant in the Tertiary beds. In the former locality, however, most of them proved so imperfect and indistinct as to be nearly useless for study; but at the latter they found a de-

posit, probably of Miocene age, astonishingly rich in insect remains, many of them beautifully preserved. During the past year about 20,000 insects have been exhumed from this single locality; and scarcely an impression has been made upon the quarries, although perhaps more labor will hereafter be required in working them. In company with Professor Lakes, of Golden, they made as careful a survey of the basin in which they occur as their short stay permitted, and estimate the insect-bearing shales to have an extent fifty times as great as the richest localities known in Europe.

The geographical and geological survey of the Rocky Mountain region under Major Powell, to which, from its departmental connection with Dr. Hayden's survey, attention is next invited, confined its operations the past season almost entirely to the central portion of Eastern Utah, an area containing about 16,000 square miles, embraced between 38° and 40° 30′ N. lat. and between 109° 30′ and 112° W. long. Nearly the whole of this region is drained by the Green River and its affluents, before it unites with the Grand to form the Colorado, and is one of the most arid, inhospitable, and inaccessible in the country. It is an elevated plateau, cut by a labyrinth of cañons and narrow gorges, and covered in many parts by hills of naked sand and clays. The western portion, however, includes broad valleys, abrupt ranges of mountains, and one plateau of considerable extent, having an average elevation of 8000 feet. The valleys, which contain large areas of excellent land, run north and south, separated by three ranges of mountains, rising in their highest peaks to from 10,000 to 12,000 feet, and are drained by streams flowing westerly into Utah Lake.

With Pleasant City, a little town about one hundred and twenty-five miles south of Salt Lake City, as a base of supplies, three parties were organized — one for geodetical and two for topographical work. The triangulation was extended over the entire area selected. The work rests upon base-lines established in former years near Kanab and Gunnison, Utah, and was connected on the east with the triangulation points established by Hayden's Survey, and on the north with those of the Fortieth Parallel Survey under Mr. King. On account of the rumored hostility of the Utes in a portion of the district (rumors which proved groundless), the trian-

gulating party was united for a portion of the time with one of the topographical parties for mutual support. This party took the eastern portion of the field, which is separated from the western at not far from 110° 30′ W. long., and includes that part of Utah above 38° N. lat. which lies east of the Green and Colorado rivers — in all about 10,000 square miles. The party carried the secondary triangulation over this district, with stations averaging ten miles apart; made a connected plane-table map of the whole, and complemented the work with orographic sketches.

The second topographical party, occupying the western portion, was assigned an area more mountainous than that to the east, embracing about 6000 square miles: in this it occupied topographical stations at average distances of about ten miles, and measured all the angles of nearly every triangle in the secondary extension; and, like the first party, made sketches and a plane-table map of the entire area.

Besides this purely topographical work, mercurial barometers were carried by each field party; and observations were made to connect every camp with the base-station at Mount Pleasant, where observations were taken four times a day, and also hourly during eight days in each month. All the geodetic points and topographical stations were also connected by barometric observations, either with the camps, the base-station, or both; and the altitudes of all located points were observed by the measurement of vertical angles.

This hypsometric work is deemed by the director of the survey to be of the greatest importance in the classification of lands, and in determining the best methods of utilizing the waters of streams for irrigation. On account of its practical utility to the agricultural industries of the country, Major Powell suggests the establishment of a hypsometric base-line from Lake Michigan to the Pacific Ocean, from which lateral lines could be run to the base-stations used for each season. The methods of levelling by which were determined the elevations of points along the Pacific Railway (now used as a general base) were not of sufficient refinement for present needs. The work requires great care and thorough discussion, and should be undertaken by the Interoceanic Geodetic Connection of the Coast Survey. New tables also should be made, based upon series of observations in

the Rocky Mountain region itself, at stations connected by careful levelling, both with each other and a determined base. Those now in use are founded on observations at somewhat distant points in Switzerland, under climatic conditions greatly different from those obtaining in the Rocky Mountains. Such a series of observations, however, would need to extend over long periods to attain the desired result.

Besides the three parties mentioned, separate geological investigations were carried on in other parts of Utah by Mr. Gilbert and by a party under Captain Dutton. The classification of lands occupied much of their attention. Mr. Gilbert traversed that portion of the drainage basin of Great Salt Lake which lies in Utah: it includes within its limits the most valuable land of the territory, as well as some of the most sterile, where the possibility of agriculture depends on the possibility of irrigation. By measuring the volumes of the streams, an attempt was made to ascertain the agricultural capabilities of the river valleys. Some of the smaller ones proved inadequate to serve the lands, otherwise arable, through which they run. East of the lake more than twelve per cent. of the district is reclaimable; while west of it only a fourth of one per cent. is of value for farming. It is also estimated that about two and one third per cent. of the whole territory of Utah can be redeemed by the utilization of the streams, but without the construction of reservoirs; and that one third part of the irrigable lands of the Salt Lake basin is now under cultivation.

An investigation was also made of the climate of the district, as recorded in the rise and fall of Great Salt Lake. Until recently, no systematic record of its fluctuations has been kept; but from inquiry among the settlers it appears that the water is now much higher than formerly. From 1847 to 1850 it was low; then for five years it rose at about the rate of one foot per annum, afterwards fell to its original level (in 1861–62), and then continued to rise until 1868, when it reached its present height—ten feet above that first observed—which, with slight fluctuations, it has maintained ever since. Since the area of the lake is much greater with this increased altitude, and the loss by evaporation correspondingly increased, the inflowing water must be one tenth

part greater than formerly. Should it fall to its former level, it is plain that the possibilities of irrigation would be diminished.

It further appears by the studies of this geologist that the system of upward and downward movements by which the mountain ranges of the valleys of Utah and Nevada were produced have continued down to the present time. Evidences of recent movements have been discovered on the lines of ancient faults. The old shore-lines of Great Salt Lake, indicated by bench-marks upon the surrounding mountains, are no longer level, but have been elevated or depressed with the displacement of the mountain masses. Differences of nearly one hundred feet are found in the immediate vicinity of the lake, where the ancient shore-lines lie a thousand feet above their present level; but the barometer indicates that the discrepancy is greater at more remote points.

The geological party under Captain Dutton explored the plateaux drained by the Sevier River and its tributaries in Southern Utah, making a special study of the distribution of the eruptive rocks, and the methods and results of atmospheric degradation. Particular attention was also given by all parties to the extent of the forests, and the fact elicited that the area where standing timber is actually found is very much smaller than the areas where the conditions are such that timber should be growing spontaneously—that is, the timber area is but a small fraction of the timber region. Since the destruction of forests by fire greatly exceeds their removal for economic purposes, the best method of preventing these fires is an important problem.

In addition to these various labors, the survey has been collecting with great care and pains most valuable ethnographic material, particular attention being paid to vital statistics, the discovery of linguistic affinities, the progress made by the Indians towards civilization, and the causes and remedies for the inevitable conflict that arises from the spread of civilization over a region previously inhabited by savages. It is believed that the publications of the survey in this direction will have a peculiar value.

Passing now to the geographical survey west of the one hundredth meridian, carried on by the corps of engineers under the immediate charge of Lieutenant Wheeler, we find that

the expedition of 1877 entered the field early in May, with a force aggregating forty men, divided into three sections. Six main and four minor parties traversed and gathered map-material in portions of Colorado, New Mexico, Texas, Utah, Wyoming, Idaho, Montana, Nevada, California, and Oregon.

A special feature of the expedition has been the elaboration of the over- and under-ground survey of the Washoe mining region, containing the well-known Comstock lode. The contour of the entire district has been completed, and will be delineated on a scale of one inch to five hundred feet; while the profiles at distances of one hundred feet, showing the position of vein-matter, ore-bearing bodies, and adjacent country rock, have been well advanced. The position and extent of the drifts have been determined at most levels, and an extended longitudinal section of the entire vein is nearly completed. In this labor the mining superintendents and local engineers have greatly assisted Mr. J. A. Church, M.E., in charge of the work, by contributions from their store of detailed maps, which show the underground openings of all the prominent mines. This special survey, when terminated, will furnish a complete analysis of all branches of silver-mining as conducted at this peculiarly interesting mining centre, typical of its kind, and will supplement the admirable work in this same district made a few years ago by Mr. Clarence King.

Data were also gathered for constructing a detailed topographical map of the Lake Tahoe region, in the Sierra Nevada, on a scale of an inch to a mile. The other field parties were engaged in surveys necessary for obtaining material for a topographical map, on a scale of one inch to eight miles, of the entire western mountain interior.

The area covered by the examinations of the geologist, Mr. A. R. Conkling, extended in the Sierra Nevada from San Andreas and Placerville on the west, to the Como Mountains on the east. This region was found to be composed of igneous and metamorphic rocks, to the almost complete exclusion of sedimentary rocks. The most common forms are diorite, basalt, hornblende, porphyry, feldspathic porphyry, and volcanic breccia. Many Tertiary Unionidæ, and also bird-tracks, were found at the quarry near Carson. Signs of glacial phenomena were noticed in many localities, be-

sides evidences of several distinct glacier systems. No very high peaks occur in this region, the loftiest being only about 11,500 feet. There are many cañons of great depth — that of the middle fork of American River measuring 3000 feet. Upon the western slope of the Sierras there is much mineral wealth, and the greater portion of this ore-bearing belt is referred by Mr. Conkling to the Archean period. Some valuable deposits also occur along the eastern slope.

During this as in previous years, zoological work has been prosecuted to the fullest extent practicable. Mr. H. W. Henshaw was attached as naturalist to the party whose area of survey extended from Carson, Nev., northward along the eastern slope of the Sierras, into the northern portion of Oregon. This region is exceptional in the number of large and small lakes found within its limits, affording an opportunity for studying the habits of western water-birds; and a large series of skins and eggs was gathered. The avifauna of this portion of the eastern slope was found to correspond very closely with that of the region southward. Various collections were also made in several branches of natural history — the fishes, grasshoppers, and butterflies receiving special attention.

The accumulation of data and material in the various branches of the survey during this year is in excess of the amounts obtained in any one of the former years. An area of about 30,000 square miles was surveyed, admitting of representation, says Lieutenant Wheeler, upon a scale of one inch to two miles. Three base-lines were measured; the number of main and secondary triangulation stations occupied, and points established latitudinally by cross-sights and the three-point method, was approximately 4000. The altitude of a large number of stations on mountain-peaks and at other prominent points was determined barometrically. More than 12,000 miles were meandered along roads and streams. Extended observations were made to ascertain closely the amount of arable, grazing, timber, mineral, and arid areas surveyed; and these examinations will hereafter form one of the adjuncts of the topographical survey proper. The parties disbanded at Ogden, Utah; Carson, Nev.; Fort Garland, Col., and Fort Union, N. Mex., between November 25 and December 10, at the close of an extended field

season of from five and a half to six months' continuous labor.

A few draughtsmen at the Washington office have been constantly employed in completing the final maps; and a temporary field-office has been established at Ogden, Utah, where preliminary reductions will be made; and from this point parties organizing can start in the early spring. Of the total area west of the one hundredth meridian maps are in progress, covering approximately 350,000 square miles, or about one fourth of the entire region.

In all the divisions of the Department of War we find a system of reports based on the fiscal, and not on the calendar year; and as our information, apart from Lieutenant Wheeler's survey, is mainly dependent upon reports prepared to cover the year's work from July, 1876, to July, 1877, our account of other work by the Engineers must to some degree correspond to the same period.

In the military department of Dakota, some attention has been given by the chief-engineer to topographical work in the field, and the collection of geographical and geological information: this was particularly the case in the expedition against the hostile Sioux in the summer of 1876. This expedition moved westward from Fort Abraham Lincoln, on the Missouri, to the Yellowstone and Big Horn rivers; and, returning, went to the relief of Major Reno after the discomfiture of General Custer.

In the department of the Platte, reconnoissances have been made following half a dozen routes through unoccupied or partially occupied country, principally centring upon Fort Fetterman, Wy., on the north fork of the Platte, and in all aggregating five hundred to six hundred miles. The longitude of Fort Fetterman was determined by telegraphic time-signals exchanged with Detroit; and meteorological observations have been taken during several months at Forts Fetterman and Laramie.

From the military department of Missouri a survey was undertaken of the sources of the Red River of Texas. The route of the party lay from Fort Elliott, in Northern Texas, directly across the numerous forks of the upper waters of Red River and back again. A stadia-line was run the whole distance—the meridian determined, when practicable, at each

camp by a portable transit; and from the line so established the azimuth of the course was taken by the theodolite and preserved by back-sights on the march. Sketches, geological notes, and meteorological observations were also taken, and some meagre collections in natural history were made. The botany has been reported upon by Drs. Wilcox and Wood, the insects by Mr. Strecker, and the geology by Lieutenant Ruffner, of the Engineers, who conducted the exploration.

The field-work of Mr. King's survey of the fortieth parallel was finished several years ago. The office-work still continues, but will soon be completed. The entire publication will consist of seven quarto volumes and an atlas, all of which have been published, with the exception of the first volume, on Systematic Geology, by Mr. King (the manuscript of which is ready), and the last on Vertebrate Paleontology, by Professor Marsh, which it is hoped will be finished the present year.

The survey of the Great Lakes and of the Mississippi River is also under the charge of the Engineers. The reconnoissance for primary triangulation has been extended from Cleveland, O., to the west end of Lake Erie, and the readings of the angles of this triangulation have been continued from Painesville to Cleveland. A beginning has also been made upon the triangulation which is to connect Lake Michigan and Lake Erie, stations having been erected for one hundred miles east from the southern end of Lake Michigan. At the same time the topography and hydrography have been carried from Vermilion, O., to the western extremity of Lake Erie, and the measurement of a primary base-line with the new Repsold apparatus, begun at Summit, Ill., was finished last summer. Astronomical work has also been continued at the observatory of the survey at Detroit, in determination of points in aid of the state survey of Michigan. Observations have been made to determine the height of the lakes. For this purpose a line of levels of precision has been run independently, in duplicate, from Escanaba, at the north end of Green Bay, to Marquette, on the adjoining shore of Lake Superior, a distance of sixty-five miles. The two lines, on reaching Marquette, differed by 31.4 millimeters, and at no point was the difference greater than 41.8 millimeters.

The highest elevation above Lake Superior which the lines traversed was one hundred and ninety meters. The resulting height of the mean surface of Lake Superior above that of Lake Michigan is 6.249 meters, or 20.5 feet. In a similar way, the line from Lake Erie to Lake Huron has been relevelled, and a preliminary reduction gives the height of Lake Superior above mean tide at New York as six hundred and two feet. Water-level observations have been continued at two stations each on Lakes Ontario, Erie, and Michigan; one each on Lakes Superior and Huron, and in the straits connecting Lake Huron with Lake Superior on the one side and with Lake Erie on the other. Six lines of soundings have been carried across Lake Erie, besides many shorter lines to complete the hydrography, for which, to mention one only of many details in this branch of the work, over 40,000 casts of the lead are reported.

The extension of the survey to the Mississippi was begun in November, 1876; its object is to construct a good map of the river, and to obtain data for any improvements needed in its navigation, and for the location of levees. The party undertaking it was instructed to base the topography on a secondary triangulation, so that the work might be the reliable base for all future partial surveys; to erect numerous permanent stone marks, determined in position and height; to run continuous lines of level along the river-bank, and also back from the river once in each mile, so as to locate contour lines for every three feet of elevation. The survey was begun at Cairo, Ill., and pushed southward for fifteen miles. A base-line a little over a mile in length was measured, and from it the triangulation was carried about seven miles, fourteen stations being occupied: the topography was carried back one mile from the shore-line. Permanent reference marks were set in three straight lines across the river, five or six miles apart, each consisting of two stones on either side of the river, placed respectively one and three half-miles from the river-bank. From old surveys made by the government in 1809–10, it appears that portions of the banks have been washed away to the depth of nearly half a mile. The character of the bottom of the river was carefully examined, and borings made near Cairo to study the old bed. A line of levels of precision was also run from

Cairo to Columbus, Ky. During the past summer the work has been carried on simultaneously at Cairo and at Memphis, and the latitude and longitude of both these places have been determined.

During the year the survey has occupied thirteen primary and fourteen secondary triangulation stations, completed one hundred and fifty-nine square miles of topography and one hundred and thirty-three square miles of inshore hydrography, and developed two hundred and four miles of shoreline. Latitudes of three and longitudes of nine places have been determined. Since 1852 it has issued fifty-six charts, on scales varying from 1 : 5000 to 1 : 40,000.

This completes the account of surveys carried on under the War Department. Turning now to the Coast Survey, which is under the direction of the Treasury, and which has by far the most complete organization for surveys of large extent and great precision, we find that its regular work was prosecuted during the past year with its accustomed energy, although Congress had greatly curtailed the appropriations in a misdirected attempt at economy in public expenditures. On the Atlantic coast the survey now presents a continuous chain from Mount Desert to Cape Canaveral. During the year progress has been made in pushing the topography eastward in Maine and southward in Florida: offshore soundings have been obtained in both regions, and local resurveys have been made of entrances where important changes had occurred. The fact that so many of our harbors are barred by sands or are encroached upon by silt demands a constant watch over the channels leading into important seaports, and no inconsiderable means are annually devoted to this end. For New York Harbor, the entrance to which is formed by narrow channels scoured by the ebb current through a cordon of sands, an annual examination is found necessary. Philadelphia, Baltimore, and Beaufort, N. C., have likewise had special surveys during the past year. An interesting examination of the salinity of the waters of Chesapeake Bay and its estuaries has been made, with a view to a study of its general regimen, and as bearing upon the important question of oyster-culture. But the most interesting part of the work during the past year, on the Atlantic coast, is the closing of the chain of fundamental

triangles extending along the southern portion of the Appalachian Mountains, and completing a continuous geodesic arc from Passamaquoddy Bay to Central Georgia. This work, with its five base-lines and numerous determinations of azimuth, latitude, and longitude, not only furnishes an exact framework for the survey of the states through which it passes, but is an important addition to our data for determining the figure and magnitude of the earth.

Pursuing our review of the work around the shores of the Gulf of Mexico, we find the survey completed from Cape Florida to the Tortugas and Cape Sable. Some long reaches are yet to be mapped between the latter point and Cedar Keys, on the west coast of Florida; but from this point to the Mississippi delta the survey of the shores is unbroken. West of this there are again several breaks until we reach Galveston, whence the survey is again complete to Corpus Christi. Offshore soundings are, however, still wanting along a portion of the coasts just cited. Deep soundings have been taken most successfully in the Gulf, developing the form of this great basin, and, by the aid of temperatures at all depths, its regimen and circulation. Work has been in progress from Tampa Bay southward, in the vicinity of Cedar Keys, on Barataria Bay, from Corpus Christi towards the Rio Grande, and on the Mississippi River northward from New Orleans. The latter work has a special value in connection with the question of securing the banks from overflow, and will be vigorously pressed—a fresh point of departure having recently been taken near Helena, Ark., whence the survey will be carried to the head of ship navigation, and will be met near Memphis by a transcontinental chain of triangles, to which I shall presently refer.

On the Pacific coast the survey has been in progress in Southern California, especially on the Santa Barbara channels and adjacent islands—a work rendered very difficult and slow of progress by fogs and haze; also north of Point Conception, above Cape Mendocino; on the coast of Oregon, on the Columbia River, and in Puget Sound. Very noteworthy is the occupation of Mount Diablo and Mount Helena, peaks of the Coast range, as the westernmost stations of the great transcontinental chain, and the observation of angles upon stations in the Sierra Nevada, forming some of the

largest triangles ever observed, and clearing at a single step the interval between the Coast range and the Sierras, one of the diagonals in the quadrilateral being one hundred and sixty-two miles long. This is part of a general scheme for uniting in one system the Atlantic and Pacific coast triangulations which about five years since was authorized by Congress; and here good progress has been made, not only by the requisite reconnoissance, but by actual triangulation.

On the southern branch of this transcontinental triangulation, the work has been actually executed from Atlanta across Georgia and Alabama, and laid out to the vicinity of Memphis. On the northern branch the scheme has been perfected to the Ohio River, and from a central point near St. Louis the triangulation has been carried westward halfway across Missouri, while the reconnoissance has been extended eastward across Illinois. Numerous interior positions have been accurately determined in latitude and longitude, by astronomical observations, and a line of levels of extreme precision between the two oceans begun. In authorizing this work, Congress provided that by furnishing the general triangulation, the aid of the Coast Survey organization should be given to those states that have provided for a topographical survey of their area. Under this provision, triangulation has progressed in the states of New Hampshire, New Jersey, Pennsylvania, Tennessee, Kentucky, and Wisconsin. It is to be regretted that all this work, looking directly towards a comprehensive scheme of a general trigonometrical survey of the whole country, has been interrupted by the failure of the last Congress to provide any means for its prosecution.

We cannot leave the Coast Survey without adverting to its perfect and beautiful maps, its "Coast Pilot," its tide-tables, published annually, and its magnetic charts; but any particular enumeration of these and other matters would carry us too far away from our present purpose.

Last spring the government instituted, under the Department of the Interior, an Entomological Commission, whose special object was to make a thorough examination into the locust evil and suggest remedies. Messrs. Riley, Packard, and Thomas were appointed, and divided between them the possible locust area, or the region west of the ninety-fourth

meridian. Mr. Riley chose for his examination the southern half of the district east of the Rocky Mountains—that is, south of Denver, or the fortieth parallel; also the western part of Iowa, and, conjointly with Dr. Packard, British America. Dr. Packard took also the entire region west of the Rocky Mountain range; and Mr. Thomas the district east of it lying north of the fortieth parallel. They hope to arrive at a complete understanding of the nature of the breeding-places of this dreadful scourge; the natural limits of its distribution east, west, and north; the area of its past invasions; the exact nature of its migrations; and what species it is which is injurious upon the Pacific coast. They will also make experiments to determine the comparative value of preventive measures.

The commission was appointed late in March, and early in April Mr. Riley was on his way to Texas. In May and June he visited Kansas; in July, Colorado; in August and September, Ontario and Manitoba. Mr. Thomas made several visits to Nebraska, Minnesota, and Iowa. Dr. Packard chose the westernmost field, and made two journeys. On the first he went to Colorado, Wyoming, and Utah; then turned north through Eastern Idaho and Central Montana to Fort Benton, and followed the Missouri 1200 miles to the western limit of the Northern Pacific Railroad. On his second trip he travelled directly to California, and from Sacramento went by way of Shasta Valley and Portland, Oregon, to Wallula, on the Columbia, and then north through Washington Territory to the British boundary, returning to California by sea. The commission therefore covered in a cursory way the entire territory, securing a general view, which future seasons may enable them to fill to better advantage. The district examined by Dr. Packard was the newest, and in some respects the most important. On his first journey he collected data tending to prove that the breeding-ground of the locust (*Caloptenus spretus*) includes a vast region between longitude 102° W. and the Rocky Mountains, and even extending beyond them in certain parts of Montana. On his second journey he found he must place the limits of its range much farther, so as to include almost the entire country between the Rocky Mountains and the Sierra Nevada; and the general result of his studies seems to be that the perma-

nent breeding-grounds of this locust extend in one direction across the entire breadth of the United States, and even pass northward to the Upper Saskatchewan; and in the other reach from the Sierra Nevada to the limits between plain and prairie east of the Rocky Mountains. If this be true, the district outside their breeding-grounds which they periodically invade is a belt of country lying east of it, about five degrees in width, and less than half as large as their natural territory.

The results attained by the commission during its first year show conclusively the wisdom of its appointment, and lead us to believe that it will be continued until the complete history, habits, and distribution of this insect are known. Only in this way can we expect to cope with so terrible an enemy.

The only other government commission coming within our field is that of Fish and Fisheries, and of this it is simply necessary to say that with its headquarters at Salem, Mass., and subsequently at Halifax, it covered its usual routine of research in marine zoology and ocean physics on the coasts of Massachusetts and Nova Scotia.

In this connection, however, mention should be made of the Smithsonian explorations, on account of the intimate relations of this institution to the government.

The natural-history exploration of Alaska has for a long time been a special object of interest with the Institution, and as early as 1865 it induced the Western Union Telegraph Company, then at work in this region, to add to its corps several skilled naturalists and collectors. Their labors were directed by the Institution, and the results have become part of the history of the progress of American science. With the acquisition of Alaska in 1867, the special operations of the Institution were renewed; and, by the hearty co-operation of various departments of the government, additional results of great value have been secured.

The most important contributions of late years have been those furnished by Mr. Henry W. Elliott, special agent of the Treasury Department, on the Pribylov Islands; by Mr. William H. Dall, of the United States Coast Survey; and by Messrs. Turner and Nelson, attached to the Signal Service of the War Department. Mr. Lucien M. Turner, stationed

for several years at St. Michael's, Norton Sound, transmitted large numbers of birds and their eggs, skins and skeletons of mammals and other vertebrates. More important, perhaps, was an extensive series of specimens illustrative of the ethnological peculiarities of the Esquimaux and other tribes. The last of these collections (received in the summer of 1877) was particularly rich in Esquimaux carvings in bone, reproducing the characteristics of the carvings of the reindeer period as found in the caverns of France and Germany.

In the summer of 1877, Mr. Turner was superseded by Mr. E. W. Nelson, who, by the last advices, had made large collections and some interesting zoological discoveries. On this, as on other occasions, the chief signal officer of the army has joined heartily with the Institution in a thorough exploration of the physical and natural features of various unexplored regions. In the same connection, due credit should be given to the Alaska Commercial Company, which, contrary to the usual policy of corporations, has gone hand in hand with the Institution in its efforts to secure a thorough knowledge of the territory, by making large and valuable collections, by instituting meteorological observations, and by supplying mineralogical, zoological, and ethnological statistics.

Since December, 1876, Mr. Frederic A. Ober has been engaged, under the auspices of the Institution, in a systematic exploration of the natural history and ethnology of the West India Islands. In the course of this work he has thoroughly explored the islands of Dominica, Antigua, St. Vincent, Barbadoes, and other points; and his collections have already furnished several new species of birds and other animals. He has also forwarded many important observations and ethnological objects illustrative of the manner of life of the scattered survivors of the Carib race, which formerly occupied the group.

One of the most important archæological explorations of 1877 was conducted by the Rev. Stephen Bowers, among the ancient ruins of the islands and mainland of Santa Barbara County, Cal., in continuation of previous researches made by him in connection with Lieutenant Wheeler's expeditions. He has secured and forwarded to Washington many thou-

sand pieces, which have been added to collections of a similar character previously obtained by Messrs. Schumacher, Harwood, Dall, and others. The expenses of these researches were shared by the Smithsonian Institution and the survey of Major Powell.

In the autumn of 1876, Mr. G. Brown Goode, assistant curator in the National Museum, visited Bermuda, and remained there until the spring of 1877. His researches on that island were exhaustive, and resulted in the discovery of many species of marine animals either new to science or previously unrecorded by naturalists from that quarter. In this work he had the co-operation of Mr. J. Matthew Jones, of Halifax, who has for many years devoted himself to the natural history of Bermuda.

Several years ago Dr. J. F. Bransford, U.S.N., while on duty with the expedition sent out by the Navy Department to investigate the practicability of constructing an interoceanic canal through Nicaragua, was attracted by the numerous remains of ancient pottery, stone, etc. In 1876 he was again sent out by the department to review some points of the route, and once more in 1877. During these later visits he made systematic researches into the archæology and natural history of Lake Nicaragua and its islands, and forwarded large numbers of specimens to the National Museum.

Let us now glance at one or two of the state surveys.

Less than two years ago the State of New York appointed a Board of Commissioners of a trigonometric and topographical survey, with Mr. J. T. Gardner as its director. Mr. Gardner has had long experience in Western surveys under Messrs. Whitney, King, and Hayden. With a small appropriation, the primary triangulation, starting from one of the United States Coast Survey triangles on the Hudson River as a base, has been extended this year over an area of about 3000 square miles, including parts of eleven counties, in which one hundred and seventy points have been located. Five primary stations have been occupied and three more observed upon. The average length of the sides of the triangles is about twenty-eight miles. All the angles were observed by Mr. Gardner himself with a twelve-inch circle reading to tenths of seconds by three micrometers. The

preliminary computations show that the errors of closure in the triangles do not exceed those of the principal surveys of Europe and this country. The secondary and tertiary triangulation has also been extended over about 1700 square miles of the same district, including the greater part of five counties immediately west and northwest of Albany. Within this area almost every town, village, and hamlet, as well as points a few miles apart along the important roads, has been located. One hundred and seventy-five miles of county boundary, including the whole or parts of nine counties, have been marked with granite monuments four feet high, and the position of a large number of them has been fixed trigonometrically. A map of this region will soon be constructed. The local surveyors have already begun to base their surveys of private property on the state triangulation, and deeds are already on record in which the position of the land is described by giving the distance and direction of the nearest survey monument—the use of the needle being abandoned.

Very little field-work has been undertaken the past season in the second state survey of Kentucky, under Professor N. S. Shaler, but progress has been made in the publications. The first four volumes of the economical reports are completed, the fifth and sixth each about half done, and matter enough has accumulated for the completion of the unfinished volumes. These volumes contain over fifty memoirs on the various resources of the commonwealth. A first volume of scientific memoirs has been published and a second commenced. Two volumes of photographic views are also ready for the press. Chemical analyses of over six hundred different samples of the products of the state have been made. Biennial appropriations are made for the continuance of this survey, which has now been in operation six years.

Pennsylvania has also its second geological survey, under the direction of Professor J. P. Lesley, which practically commenced work in June, 1874, with appropriations providing for its continuance until the close of next year. Professor Lesley has kindly furnished so admirable a digest of its operations that it is given in very nearly his own words. A small part of it has reference to the earlier as well as the

later years of the survey, but it will be none the less interesting on that account.

The state was not regularly divided into districts, but the least-known portions were surveyed first. Five district surveys were organized: one in the azoic rocks; one in the Lower Silurian iron-ore limestone belt; one in the Upper Silurian fossil-ore belt, taking in the ore belt of the Lower Devonian; one in the oil-field, and one in the bituminous coal-field. Afterwards two other districts were occupied—one that of the Chemung rocks of the northern counties, and another in the bituminous coal-field.

Gradually the number of independent assistant geologists was increased, so that in 1877 Professor Stevenson, Professor White, Mr. W. G. Platt, and Mr. Ashburner have surveyed separate parts of the bituminous-coal area. Mr. Carll and Mr. Chance have together continued the survey of the oil region. Mr. Sherwood has made colored outcrop maps of three northern counties, in addition to three previously made; Mr. Franklin Platt has finished Blair County; Mr. Chance has finished a large contour-line map of the Upper Juniata limestone region; Mr. Billin has half finished a large contour-line map of the Buffalo mountains; Mr. Sanders has nearly half finished the contour-line map of the South Mountain range; Mr. Berlin, under the direction of Professor Prime, has finished the limestone belt iron-ore map as far west as Reading, and commenced the contours of the mountains between the Delaware and Schuylkill rivers; Professor Frazer has finished a survey of Lancaster County; Mr. Sanders has laid in the outcrops of Cumberland County, and Mr. C. E. Hall and Mr. Fellows have made large collections and traced outcrops along the Philadelphia belt of azoic rocks.

No changes have been made in the *personnel* of the corps since its organization. The work is harmonious, the members zealous, and the results large—some of them new and unexpected; but in the main the accuracy of the old survey of 1835–41, under the brothers Rogers, has been satisfactorily established.

The function of the new survey is one of differentiation and precision. The contour-line maps, on a large scale, based on a reticulation of transit and level work, are its best illustration. A multitude of connected, measured, vertical

sections, throughout the bituminous coal-field and oil region, will leave nothing to be desired there in the permanent stratigraphical definition and classification of the coal measures of the state. A new and brilliant light has thus been thrown upon the geology of coal. Another year's work will give nearly all that is needed on the subject of glaciation. Nothing whatever has yet been done in the anthracite field. The materials for it, accumulated by the railroad and coal companies, are beyond calculation, and only need collation and publication to make such a survey complete.

Thirteen octavo volumes of the survey have been printed and distributed, two more will shortly be published, and three others are going through the press. Two volumes are ready for the press and will soon be in hand; and ten volumes will be prepared this winter for printing in the spring of 1878. With the exception of three volumes of chemical analyses, one of oil-well records, one of railway and other levels, and one by Professor Lesquereux on the flora of the coal, these thirty volumes form a library of local county geological reports. Exhaustive indexes, geologically arranged, give them, however, a scientific value. The county maps published with them will be followed by a small pocket atlas of colored geological county maps of the state.

The only object of the present survey is to put the geology of Pennsylvania within reach of every citizen of the state. If geologists find new knowledge in its publications, it is clear gain; for they are not written for geologists, but for the common people of Pennsylvania. Accuracy and completeness are the only desiderata kept in view.

The Geological and Natural-history Survey of Minnesota, though small in proportion to the preceding, possesses an independence of political influences and a stability which make it particularly worthy of our attention. It has just completed its sixth year, and is established on a secure though small financial basis, being under the supervision of, and making its reports to, the regents of the state university. It seems destined to do a good work for the state, so far as geology and the kindred sciences are concerned; but the only basis for its topography appears to be the determination of the latitude and longitude of certain points

through the assistance of officers of the United States Lake Survey.

Detailed geological surveys have been made in 1877 in Ramsey, Rice, Pipestone, and Rock counties; and preliminary surveys in Goodhue, Wright, and Morrison counties, as well as along the line of the Northern Pacific and St. Paul and Duluth railways. A careful investigation has been made of the domestic water-supply in the Red River valley. The famous pipe-stone quarry has been described and mapped. Paleontological and chemical studies have been carried on in the laboratory, and the ornithologist and entomologist have been active in the field. The latter has made valuable observations on the ravages of the destructive locust.

The following are the most important results of the year: Evidence has been obtained by Professor N. H. Winchell, the geologist in charge of the survey, indicating the presence of Upper Trenton strata in Ramsey County, where its lithological and paleontological characters bear so close a resemblance to those of the typical Cincinnati group as to suggest that the term Cincinnati may elsewhere have been wrongly applied to true Trenton limestones. The shaly condition of the rocks is believed to be due to the greater proximity of the old azoic axis of the continent, causing coarser sedimentation.

A study of the more recent deposits shows that in the southwestern part of Minnesota the loess loam enters the state from the south, becoming gradually coarser in going north, with gravel-stones and pebbles, until it passes into a stony clay and at last into a true boulder clay, apparently continuous with the later boulder clay of the drift period. This would show the loam of the great rivers and lake valleys of the West to be simply the drainage from the vast drift accumulations formed further north at the time of the last glacial epoch.

The investigation of the drinking-water in the Red River valley was made because it had been feared that the noxious odors which prevail in wells sunk in this district, and which had proved disastrous to the health of the inhabitants, were due to the nature of the soil itself, and would always render the region unhealthy. It was found that the trouble extended over the whole western-prairie portion of the state, and

was simply due to the persistent use of pine plank in walling the wells. Stone having to be brought from a distance, the early inhabitants have naturally taken the most available timber; and since the drift in which the wells are sunk is a tight clay, the decay of the sap and pitch of the wood has been confined to the water, instead of being carried away by easy drainage and gravelly subsoils.

This by no means exhausts the number of states in which surveys of one kind or another—principally geological—are in operation. Alabama, Georgia, Mississippi, North Carolina, and Tennessee, in the south; Indiana, Michigan, Missouri, New Jersey, Wisconsin, Rhode Island, and perhaps Kansas, in the north — all have persons employed with a larger or smaller force, with or without pay, making regular or occasional reports to legislatures or boards of agriculture. Probably the number could be increased. And surveys on a somewhat extensive scale have just been completed in New Hampshire, Ohio, and Illinois. In most cases, however, these surveys now in progress have mainly a local interest; and I have not, therefore, attempted to obtain special information concerning them.

There have also been a few private explorations of some interest; although during the past year comparatively little has been done excepting by the Peabody Museum of Archæology at Harvard College. Under the auspices of this new institution, Dr. E. Palmer spent ten months in Southern Utah and Northern Arizona exploring the ancient mounds. These are not such as have been used for burial, but appear to be formed by the successive ruins of mud-houses; one house being built upon the levelled heap which the ruins of an earlier one furnished, and, in its turn, giving place to another, when the first has been levelled by atmospheric agencies. They are therefore mounds of residence, or ancient dwelling-sites; and a considerable variety of curious pottery has been found in them. Similar pottery was found by Dr. Palmer in some rock-caves in the same region; and both are probably to be referred to the old Pueblo race. Dr. Palmer also made zoological and botanical collections of considerable interest, coming as they do from regions seldom visited by naturalists, discovering a number of new plants and insects. He has recently gone, in the interests of

the museum, to Mexico, accompanied by Dr. Parry, who will devote himself to botany.

Mr. Paul Schumacher has been exploring the island of Santa Catalina, off the southern coast of California. He has made some interesting discoveries concerning the manufacture of large stone pots, which, until the arrival of Europeans, or before 1650, the Indians made from steatite. He has found them in all stages of manufacture, and has even discovered the place whence they obtained the steatite. He also explored their burial-places.

Mr. Henry Gillman has been engaged in the same work in the burial-mounds of Florida, but no returns have yet been received.

Dr. C. C. Abbott has continued his examinations of the drift-gravel of New Jersey with most interesting results, bringing to light what is deemed conclusive evidence of the existence of man on this continent during the glacial epoch. In gravel acknowledged by Hunt, Pumpelly, and Shaler to be either of glacial or interglacial age, he has found a large number of stone objects, unquestionably fashioned by artificial means. The discovery of implements in so many places where their presence cannot be referred to mere accident leaves no doubt in the minds of those who have examined the evidence that the conclusion of Dr. Abbott is essentially correct.

Finally, the curator of the museum, Mr. F. W. Putnam, spent a portion of last summer exploring the mounds, stone-graves, and earthworks of Tennessee. He believes he has obtained conclusive proof that the localities so frequent in the West, surrounded by embankments of earth upon an extensive scale, were sites of villages, the embankments being purely protective. This is opposed to the views of Morgan, who maintains that the village houses were built upon the encircling mound, and opened into the common area, where vegetables were grown. As relics of the mound-builders, Mr. Putnam brought home a large collection of skeletons, pottery, stone implements, pipes, and various articles of shell and bone. Seven perforated pearls were also found, and four copper articles. Parties are still in the field extending these explorations.

I have to mention one more expedition, which, though it

has nothing to do with our own territory, possesses an interest peculiar to itself. I refer to the north-polar expedition organizing by Captain Howgate, of our army. His plan is to establish a colony of fifty men, under military discipline, including three commissioned officers, two surgeons, an astronomer, and two or more naturalists, upon some point north of the eighty-first degree of latitude, on or near the shore of Lady Franklin Bay; to provision this party for at least three years, sending them annual supplies and recruits, and thus to make the colony the base of expeditions towards the pole. This differs from preceding plans, in leaving the party with no means of return until their work is accomplished; the only use of the ship being in transporting the men and supplies. They are to burn their bridges behind them. The advance to the pole is to be made with dog-sledges, and the men are to live like the Esquimaux.

This plan would certainly merit our heartiest commendation, did it not overestimate the importance of one single point—reaching the north pole. "From the post so formed," says Captain Howgate, speaking of his proposed colony, "no time will be spent in needless quest along the shore, either east or west." The colony will "have their work narrowed down to a common focus—the pathway due north." This is certainly a fatal error. It is of little consequence to geographical or any other science whether the pole be ever reached, however much the stimulus of adventure towards the pole may be needed to tempt men to explore high latitudes. But the knowledge which may be accumulated through such a colony, by explorations in every direction, would be of incalculable value, and, under proper direction, might form an addition to our knowledge of geology and terrestrial physics such as could never be gained elsewhere. Nowhere else can we so readily study the phenomena of the glacial epoch, the influence of which still shapes our lives and modifies all our surroundings. In no other quarter of the globe, as Professor Loomis has pointed out, can we make observations on the phenomena of magnetism, of atmospheric electricity, of the currents and varying temperatures of the air and water, which would possess so much importance in solving meteorological and other problems; while as to geography proper, nothing whatever is known of that re-

gion but the bare shore-line, and even that is fragmentary. So far, then, from its being true that "surveys there have already been completed," as Captain Howgate urges, there is no quarter of the globe where more work is demanded, or where the result could be turned to better account. And Captain Howgate's plan must be placed upon a broader basis, if the expedition would expect to compete in any way with those fitting out by other nations.

Captain Howgate's faith in the ultimate approval and support by Congress of his plan of exploration has led him to fit out a preliminary arctic expedition to prepare the way for the main party, which, it is hoped, will organize the present year, and reach the Greenland coast by the middle of August at latest. This preliminary party sailed from New London in the *Florence*, a schooner of fifty-six tons, on the 2d of August, and reached Cumberland Gulf on September 13. Advices from them at the end of September announce their intention of moving at once into winter-quarters at the head of the gulf, near latitude 67° N. The party consists of thirteen persons, including a meteorologist and photographer, Mr. O. T. Sherman; and a naturalist, Mr. L. Kumlein, sent out by the Smithsonian Institution. They are expected to bring together ten Esquimau families, with their dogs and sledges, and fur clothing sufficient to supply fifty persons for three years, with other stores in readiness for the main party next year. They will also make meteorological observations and collections in natural history. When, next year, they have turned over the colony's outfit to the new party, they expect to capture and bring home a cargo of bone and oil sufficient to defray a part, at least, of the expenses of the trip. Notwithstanding, then, the failure of Captain Howgate's plan before the last Congress, we have an American party, with scientific men attached, stationed this winter within the Arctic Circle.

MICROSCOPY.

By Professor HAMILTON L. SMITH,
HOBART COLLEGE, GENEVA, N. Y.

LIMITS OF VISION.

Reasoning on certain data more or less theoretical, mathematicians of the first order, notably Helmholtz, had concluded that the limit of vision had been reached; that the optician could practically aid us no further; that, in short, the limits of possibility had been arrived at, since light itself is too coarse to reveal objects smaller than those visible to our finest and most powerful lenses. The limit marked out was about the one-hundred-and-eighty-thousandth of an inch. Recently the Rev. Mr. Dallinger, in a note read before the Liverpool Microscopical Society, gave instances of a remarkable kind—the result of his personal investigation, directed specially to this point—which were proved, by a method of measurement employed specially for the purpose, to carry the power of our most delicately constructed lenses considerably further than the mathematician considered possible, revealing, indeed, smaller objects than those mathematically indicated; and Mr. Dallinger did not by any means believe that he had wholly exhausted the power of visibility by these experiments. In reference to the same subject Mr. W. Webb states, in the *Monthly Microscopical Journal* for October, that Mr. Crisp, of London, has in his possession a diamond engraving of the Lord's Prayer in which the letters are smaller than the two-hundred-and-ten-millionth part of a square inch, at which size over fifty-nine Bibles would be required to cover an inch. Mr. Webb criticises somewhat severely the paper of Mr. Rogers, of Cambridge, Mass., "On a Possible Explanation of the Method employed by Nobert in Ruling his Test Plates," and makes some very obscure statements, to the effect that the spurious lines are caused by polarization of the light! According to the results of the undulatory theory of light, the size of the fringes of diffrac-

tion of a bright disk or line of light, which are capable of totally obscuring an object of less diameter than these fringes, varies as the natural sine of the half angle of aperture for the same wave of light. Now the half wave-length for an extreme aperture of nearly 180° is, upon this theory, the $\frac{1}{92364}$ of an inch, which approximates very closely with the measurements of that very difficult test diatom, *Amphipleura pellucida.* It would seem, therefore, that the statements of Mr. Webb as to the minuteness of the letters in the Lord's Prayer, as mentioned above, must be erroneous. Those who are interested in the question of the present limits of vision will find many useful hints in Dr. Royston-Pigott's paper in the above-named journal, and from which we extract the following notice of the application of the formula of Helmholtz. From the experiments of Mr. Broun, F.R.S., who found that a dark-brown hair 0.0026 inch wide and 2.5 inches long was visible by a young eye against a northwest sky at thirty-six feet distance, subtending at that time $1\frac{1}{4}$ seconds of arc, it follows that such an eye can actually see lines on glass $\frac{1}{10000}$ of an inch wide and $\frac{1}{28}$ long; and if such be the power of the naked eye without a lens, it ought to follow that the $\frac{1}{100000}$ of an inch ought to be seen by the same eye with a power magnifying ten times. Now Nobert's lines, if the interspaces are the same width as the lines, when they are 112,000 to the inch, would have an absolute diameter of $\frac{1}{224000}$ of an inch; and as such a line would at ten inches distance subtend one ninth of a second nearly, a magnifying power of a little over five hundred diameters should make a visual angle thirty times greater than Mr. Broun's result above stated. We must conclude, therefore, with Dr. Pigott, that although theoretically, and for brilliant lines and points, the separable interval may be for the widest aperture *half a wave-length*, yet when by proper precautions of illumination the diffraction can in a great measure be destroyed, the limit is much smaller than the one assigned.

APPARATUS AND OBJECTIVES.

In the *American Naturalist* for December, Dr. R. H. Ward briefly reviews the exhibition of microscopes at the Centennial Exhibition. The Continental microscopes were chiefly represented by the exhibit of Nachet, the English depart-

ment by that of Ross, so far as attractiveness of appearance was concerned, for R. and J. Beck's exhibit was more complete, but badly displayed; Crouch also exhibited a full series of instruments of excellent workmanship and at moderate prices. The only American display of any note was by Zentmayer, of Philadelphia. Messrs. Bausch and Lomb, of Rochester, however, exhibited a large series of entirely new designs, elaborated under charge of E. Gundlach, formerly of Germany, and chiefly remarkable for excellent workmanship and high optical qualities at greatly reduced prices. The other American exhibitors were T. H. M'Allister, George Wale, and J. W. Queen and Co. Powell and Lealand, Hartnack, Zeiss, Spencer, and Tolles were conspicuous by their absence.

In the *American Journal of Microscopy* for April, the well-known optician Mr. E. Gundlach describes two new illuminating-glasses for the microscope. One is a hemispherical lens, which is connected to the object-slide by a drop of water or glycerin, and of such thickness that the converging rays from the mirror undergo no refraction at the first or convex surface, but, on emerging from the plane surface, or, better, the glycerin, are powerfully refracted, but almost without aberration, as the centre of the curve is in the optical axis of the microscope, and the object itself is very nearly in the centre of curvature. The other is an oblique light-projector, distinguished from the condenser by the fact of the lower surface being plane instead of convex, and parallel with the upper one.

In the April number of the *Monthly Microscopical Journal*, Rev. S. G. Osborne describes a modification of Reade's "kettle-drum" illuminator under the novel name of the "Exhibitor." Like most other devices of this class, the practice and patience required to master it will more than counterbalance its advantages (if, indeed, it really have any) over the simpler and easier modes of illumination.

In the *Monthly Microscopical Journal* for August, 1877, Surgeon J. J. Woodward, Brevet Lieut.-Col., U.S.A., describes a simple device for the illumination of balsam-mounted objects for examination with immersion objectives whose "balsam angle" is 90° or upwards. A truncated rectangular prism of glass, supported base upwards upon a similar trun-

cated metal prism, is connected with the lower face of the glass slide by interposition of a drop of oil of cloves. Rays transmitted through this prism will, of course, not be received into any dry objective, or any immersion one of less than 90° balsam angle when transmitted through balsam-mounted objécts. With those objectives, however, that will admit such rays (giving a bright field) and are properly corrected, the *Amphipleura pellucida* is readily resolved in balsam. In the same journal is a note on a new "Paraboloid Illuminator" for use beneath the microscope stage, by James Edmunds, M.D. It is a modification of the well-known Wenham parabolic illuminator, much smaller, and made with great care—being, in fact, a paraboloid lens, of glass, of low refractive index, carefully cut off at a point about one twelfth of an inch below its *latus rectum.* The truncated surface is connected with the under surface of the slide by glycerin, and suitable stops, etc., are applied under the lens.

HISTOLOGY.

Dr. J. G. Richardson, of Philadelphia, having obtained specimens of blood from the several individuals of different parts of the world who went to the Centennial Exposition last autumn, after measuring carefully every isolated circular red disk, cautiously avoiding those that manifested even slight departures towards an oval form, arrived at the following results, which we condense from the tabular view given in the *American Naturalist,* March, 1877: 1400 corpuscles were separately measured; the average size was $\frac{1}{3224}$ (0.007878 mm.), the maximum was $\frac{1}{2777}$, and the minimum $\frac{1}{4000}$ of an inch. Of these, 1158, or 83 per cent., measured between $\frac{1}{3448}$ and $\frac{1}{3030}$ of an inch, a difference of size scarcely discernible with a power of 200 diameters; about eight per cent. were less than $\frac{1}{3448}$, and nine per cent. more than $\frac{1}{3030}$ of an inch in diameter; the total number $\frac{1}{4000}$ of an inch across was six, or less than one half of one per cent.; and the total number $\frac{1}{2777}$ of an inch in diameter was ten, or less than one per cent.

Herr Ebner, in a memoir on the histology of the hair, presented to the Academy of Sciences, Vienna, July 12, states that the inner root sheath is essential for hair-formation; and though broken through by the hair, it grows during the whole hair-vegetation, in the lower part of the follicle, with even

greater rapidity than hair. He defends Langer's view that new hairs are formed in the old follicle and on the old papilla.

In the *Monthly Microscopical Journal* for June is a note, with illustrations, from a paper by W. Blythe, M.R.C.S., on the "Microscopical Active Principle of the Cobra Poison," published in the *Analyst.* Magnified 250 diameters, it appears as long, slender, prismatic, and radiating crystals; and so terribly active is this substance, for which the name *cobric acid* has been proposed, that one fifth of a grain injected into a man's veins would be fatal. So that we have here a rival to aconitia, weight for weight, in its power of destruction.

STAINING AND MOUNTING.

The new double staining, by the mixed boracic solutions of carmine and indigo carmine (sulphindogate of potassium), as suggested by Merkel, promises very interesting and useful results, though as yet very unequal, probably owing to the action of the oxalic acid, into a solution of which the preparation must be put after the staining, to fix the indigo blue, but which often destroys the carmine, or changes it to a yellow color. The blue boracic solution of indigo carmine by itself is highly recommended by Mr. Golding Bird. It stains rapidly, is well fixed by the oxalic process, and is of a very agreeable color. An account of the action of these dyes may be found in the *American Journal of the Medical Sciences*, January, 1877.

Mr. T. S. Ralph, in the *Science Gossip* of October, proposes chloral hydrate as a medium for mounting, since it will dissolve and unite perfectly with many gums, resins, and alkaloids, so that we may obtain mediums varying from a fluid to a jelly-like or gum-like consistence.

BACTERIA, ETC.

Signori Lauri and Terrigi have been conducting a series of experiments upon the so-called Campagna marsh poison. They find in the endochrome of algæ growing on the Campagna and Pontine marshes minute dark granules, belonging to the group of pigmented *sphærobacteria* of Cohn (*Bacterium brunneum* of Schroeter), and yielding *Monila pencillata* of Fries on cultivation, and which appear to be identical

with the "pigment granules" present in the liver, spleen, and blood of persons who have suffered from malarial diseases; and by cultivating such granules from a human liver Lauri obtained a *Zooglœa.* On the basis of these observations, the prevalence of malaria at certain seasons is explained by the immense numbers of sphærobacteria in the air, rising from the dead and decaying algæ as the waters sink in the marshy pools, and which, swept hither and thither by the wind, excite malarial diseases when they penetrate into the human body.

The *Bacteria* of Denmark have recently been studied by Dr. Eugene Warming, and an abstract of his paper upon them is given in the *Journal of Botany* for December, 1876. All along the Danish coast there is found, during calm weather, a red coloration of the water close to the shore, chiefly due to *Bacterium sulphuratum*, under which name are united a number of forms, appearing, 1st, as spheres (*Monas vinosa*, E.); 2d, as roundish bodies with constriction and granules at the ends (*Monas Warmingii*, Cohn); 3d, like *Monas vinosa*, but crowded with sulphur grains (*Monas erubescens*, E.); 4th, long, narrow, cylindrical, and filled with sulphur grains (*Rhabdomonas rosea*, Cohn); finally, the series is closed by a spiral form. Besides these, many other species are pretty fully described.

In a letter addressed to the Secretary of the Royal Society, London, under date February 14, 1877, Dr. Tyndall states that heat discontinuously applied is a "*germicide*," and that, even in the midst of a virulently infective atmosphere, it is possible to sterilize all infusions by a temperature lower than that of boiling water. This is effected, however, not by a simple substitution of time for intensity, but depends solely upon the manner in which the heat is applied. The secret of success is to apply the heat for a period not exceeding the fraction of a minute in duration, during the period of latency preceding the clouding of infusions into visible *Bacteria*, and while the germs are being prepared for their emergence into the finished organism. As they reach the end of this period successively, the heating process must be repeated at intervals, so that the softened and vivified germs on the point of passing into active life are killed as they arrive successively at this stage. After a number of repetitions

not amounting altogether to five minutes in the aggregate, and at a temperature lower than boiling water, and commencing with the first application of the heat a few hours after their preparation, the most obstinate infusions were completely sterilized; while other samples of the same infusions, boiled continuously for fifteen or even sixty minutes, were only less fertile, and after a short interval developed swarms of *Bacteria.*

Dr. Bastian has recently read before the Royal Society a paper giving an account of some further researches "illustrative of the physico-chemical theory of fermentation, and the condition favoring archebiosis in previously boiled liquids," summing up as follows: The experiments show, as others have done, that an exclusive germ theory of fermentation is untenable, and that living matter may, and does, originate independently during the progress of fermentation in previously germless fluids; insoluble products reveal themselves as specks of protoplasm, "living" matter, emerging gradually into the region of the visible, and speedily assuming the well-known forms of one or other variety of *Bacteria*, thus bridging, as he conceives, the narrow gulf between certain kinds of "living" and "dead" matter, and affording the long-sought-for illustration of the transition from chemical to so-called "vital" combinations! In the *Lancet*, Aug. 5, will be found an interesting note upon M. Pasteur's reply to Dr. Bastian on the heterogeny controversy. M. Pasteur, while admitting that Dr. Bastian's experiments, as detailed in his communication to the Paris Academy of Sciences, are very accurately conducted, asserts that a temperature of 50° C. (122° Fahr.) is not sufficient to kill the germs of the minute organisms which may be introduced by means of the solution of potash employed by Dr. Bastian. He considers it fully proved, from his own experiments, that the germs of certain organisms, which do not resist a temperature of 100° in acid solutions, are capable of such resistance in neutral or slightly alkaline fluids. He expresses the hope that Dr. Bastian will abandon his faith in spontaneous generation, and classes its supporters with the theorizers in physics and mathematics who believe in perpetual motion or the quadrature of the circle. Professor Tyndall, after having read Pasteur's reply, gives entire adherence to his views, and calls "on all enlightened

persons to banish from science this doctrine of spontaneous generation, which has nothing whatever to support it." In a recent communication to the *British Medical Journal*, Professor Roberts, of Manchester, commenting on Dr. Bastian's claims, states that his experiments are decidedly in favor of Pasteur's conclusions, and, indeed, that to a logical evolutionist there would appear to be a strong *a priori* improbability in the abiogenic origin of *Bacteria*. When Pasteur says that abiogenesis is a chimera, he prudently adds, "in the present state of science;" and, even thus qualified, the expression is perhaps too strong. But it is absolutely certain that up to the present time no case of abiogenesis has been presented which has stood the test of accurate investigation. Dr. Tyndall has recently repeated at Kew, where he found a purer atmosphere than at the Royal Institution, his last year's experiments with perfect success, and without the annoying failures due to the atmosphere of the Institution being laden with germs from a quantity of hay, and has thus once more proved his case against Dr. Bastian. In every experiment but one the specimens showed no trace of life; in that one a small aperture like a pin-hole was in the side of the test-tube. Dr. Tyndall's paper is published in the *Proceedings* of the Royal Society (No. 176). In the *Quarterly Journal of Microscopical Science* for July, Mr. Jeffrey Bell gives an account of recent researches in the history of the *Bacteria* made by and under the direction of Professor Colin.

Professor Tyndall has shown that in air which is optically pure—*i. e.*, which will transmit a beam of light without revealing its path—sterilized but putrescible fluids remain sterile. If, however, the same fluids are put in contact with an atmosphere charged in the ordinary way with motes, they become "infallibly smitten" with putrescence. The inference is that germs or spores, or the bacterial equivalents of these, must be among the motes or particles in the atmosphere, and that their development depends upon the deposition in suitable fluids. In order to test this theory, the Rev. W. H. Dallinger has recently made numerous experiments with a sterile putrescible fluid, exposed alternately to an atmosphere charged with organic germs of extreme minuteness and to one optically pure. The results of these experiments are detailed in the December number of the *Monthly Microscop-*

ical Journal. Enormous numbers of the *calycine* and *springing* monads, when entering freely into the spore-emitting and sac condition, were carefully heated at a temperature of 150° Fahr. until quite dry, flaky, extremely friable, and crumbling into dust with the least pressure. Suitable vessels, covered, and partially filled with a nutritive fluid, were placed in a chamber, the air of which could be optically tested for the presence of motes or germs by transmitting the condensed beam of an oxyhydrogen lime-light. At the end of four days the searching beam still showed the presence of floating motes, though in greatly diminished quantity, and a few of the vessels, which had meanwhile been uncovered, were now examined. In every drop from these the larger or *calycine* monad was found, but the *springing* monad was comparatively rare. Two days after, four of the vessels, which had in the meanwhile been opened and exposed to the air with the diminished number of motes, were examined, and proved to be almost destitute of the *calycine* monad, but the *springing* monad was much more abundant. The explanation of this is, that the heavier germs of the larger monad had nearly all fallen before the expiration of two days, but those of the smaller were still lingering in the air. To test this still further, an infusion twelve months old, and composed almost entirely of the very minute *uniflagellate monad,* was carefully dried at 150° Fahr., reduced to fine powder, and intimately mixed with that containing the *calycine* and *springing* monads, and diffused in a chamber so that the air could be tested as before by the beam of light. When all the larger particles had fallen, nine vessels of the nutritive fluid were introduced. Three of these were open; the rest were covered. At the end of twenty-four hours two more were opened, and the remaining four were uncovered at the end of forty-two hours. The first set, on examination, yielded all the forms in the ratio of their magnitude, the next set was almost entirely destitute of the larger forms, and the last four absolutely so. Each set was exposed five days. Afterwards, when the beam showed the air to be moteless, four more vessels with the same nutritive fluid were exposed for five days, at the end of which time not a trace of a monad could be found in any of them; and *Bacteria* which had been more or less present in all the other instances were

only sparsely to be seen. The inference is irresistible that in regard to the very minute *Bacteria* germs, though we do not yet know how they are produced, nor can we detect them with the microscope, yet they do exist, and remain floating long after all others are deposited.

M. Pasteur asserts that *Bacteria* present themselves under two forms—first as rods, which alcohol, compressed oxygen, desiccation, and a temperature lower than 100° C. can destroy; and, secondly, as highly refracting corpuscles, which, on the other hand, resist a temperature of 120° C., and resist also the action of alcohol and of compressed oxygen. These he regards as a mode of generation of the *Bacteria*. They do, of course, also multiply by segmentation; but often, on one or several points of the *Bacterium*, globular, highly refracting corpuscles arise, the diameter of which is not greater than the thickness of the *Bacterium*. After these appear, the rest of the rod quickly disappears. If an appropriate liquid is inoculated with these corpuscles, *Bacteria* are developed in it, just as if the liquid were inoculated with rod-like *Bacteria*, and they constitute the resisting power of the liquids experimented on by some authors.

MONADS AND AMŒBÆ.

Herr Cienkowsky, well known for his researches on monads, has recently contributed some additional information upon these and allied organisms, which appear to show that the boundary-lines which it has so long been usual to draw between plant and animal organisms, and between the individual groups of those lowest forms of life, appear more and more illusory, and the supposition is recommended of a common lowest kingdom of organisms, that of *Protista* (Haeckel), out of which animals and plants have by degrees been differentiated.

At the meeting of the Philadelphia Academy in October last, Dr. Leidy gave an interesting account of a cannibal *Amœba* (*A. limax?*), which, after a period of seven hours, succeeded in digesting, or at least absorbing until it disappeared among the granular matter of its *entosarc*, another *Amœba* (*A. verrucosa*), thus appropriating its structure to its own, just as we might do a piece of flesh completely, without there being any excrementitious matter to be voided.

Professor Leidy states, in a paper read (June 12) before the Academy of Sciences of Philadelphia, that most of the known parasitic Infusoria possess a mouth similar to those which live in ordinary water. Such is the case with the species of *Balantidium* found in the intestinal canal of man, the hog, and various batrachians; of *Nyctotherus*, in the intestines of frogs and insects; and *Conchophthirus* found abundantly on the branchia and palpi of *Anadon fluviatilis.* Other parasitic Infusoria are devoid of an intestinal canal, and absorb nourishment through the body like the tapeworms and Echinorhynchi. In the same paper he describes a new infusorian found in the rectum of a *Paludina* under the name *Anoplophrya vermicularis.*

FORAMINIFERA, ETC.

Professor Hertwig announces the discovery of nuclei in Foraminifera, already independently observed by Schulte, but which, singularly enough, had not been detected by the naturalist on board H. M. S. *Challenger*, who devoted so much time and attention to the pelagic Foraminifera. Although Hertwig's observations do not as yet prove *all* Foraminifera to be nucleated, probably they really are so; and as the whole of the soft body of a many-chambered *Polystomella* or *Rotalina* normally has but a single nucleus, it follows that the whole animal has but the value of a *single cell*—or, in other words, that the Foraminifera at large must be regarded as *unicellular animals.*

In the *Proceedings* of the Royal Society, No. 170, Mr. J. Murray gives a report of the *Challenger* expedition, and remarks especially, with reference to *Globigerina* ooze, that it was not found in any of the enclosed seas in the Southern Ocean south of latitude 50° S., nor in the North Pacific north of latitude 10° N. In the Southern Ocean, only one small species was found in the surface waters. The *Globigerina* ooze occurs in irregular patches at depths less than 1800 fathoms; but its presence or absence at greater depths is determined by conditions at present unknown. Some specimens are white, others rose color, and others red or dark brown from the presence of oxides of iron and manganese.

Dr. Bessels, of the *Polaris* expedition, has given the name *Protobathybius* to a form which is considered as allied to the

simple *Monera*, being drop-like masses of protoplasm, even without a nucleus, and discovered in Smith Sound. It is extremely doubtful whether this is an organism; possibly it may be only a portion of the jelly-like secretion which is produced so abundantly in the deep-water growths of the diatomaceæ.

ZOOLOGY.

Mr. F. Buckland states, in a late number of *Land and Water*, that the green-bearded oysters found not far from Southend, Essex, owe their green color to the sporules of the sea-weed called "crow-silk," which grows abundantly in the Roach River; and that chemical analysis does not show the slightest trace of copper or other mineral, while the vegetable pigment itself imparts a peculiar taste and agreeable flavor to the meat of these plump little oysters.

At a recent meeting of the Academy of Natural Sciences at Philadelphia, Professor Leidy explained a seeming phosphorescence of the water observed in cloudy afternoons as due to the reflection of light from minute mirror-like appendages of small crustaceans. He also exhibited a tape-worm said to have been taken from the inside of a large cucumber!

In some researches on *Filaria hematica*, made by MM. Gatch and Pourquier, and published in *Comptes Rendus* December 27, 1876, they found these worms in the blood of the fetus of a bitch whose heart was filled with them; but they do not explain how they traversed the double walls of the placenta in order to pass from parent to offspring.

The *Poduridæ*, or "spring-tails," of Sweden have been monographed in an elaborate way by T. Tullberg. The memoir is accompanied by twelve plates, and enters quite fully into the anatomy of these little creatures of so much interest to microscopists. The work appears in the *Transactions* of the Royal Swedish Academy.

BOTANY.

Not long since, it was thought that the want of chlorophyl determined the parasitism of plants, as well as serving to distinguish between fungi and algæ. The discovery of a chlorophylaceous fresh-water alga as a bright emerald-green parasite by Professor Cohn, in 1872, was the only known exception. At a late meeting of the Dublin Microscopical

Club, Professor E. P. Wright exhibited and described a second species, marine, found growing and developing itself in the mucilaginous tubes of a *Schizonema.* It is smaller in size than Cohn's species, but with an emerald lustre scarcely less than that of the fresh-water species. It seems to be thus established that chlorophyl-bearing plants sometimes need, and are capable of assimilating, already formed carbon compounds, hitherto supposed to be only a characteristic of the fungi.

In the *Monthly Microscopical Journal* for January, 1877, Mr. Worthington G. Smith has an interesting paper called "Notes on Pollen," and illustrated by four plates, which show how extremely pollen grains differ in size, form, and external marking; giving sometimes a valuable clue to a plant's relationships, though sometimes pointing in various contrary directions, since plants have not descended one from another in a straight line, but possess complicated relationships with plants belonging to several different natural orders.

In a paper read before the Royal Society and printed in No. 179 of their *Proceedings*, Mr. F. Darwin, M.B., maintains that the glandular hairs, or trichomes, found on both surfaces of the leaf of the common teasel (*Dipascus sylvestris*) contain true living protoplasm, inasmuch as they undergo violent contraction upon application of reagents of widely different natures, but not with osmic acid, which, it is well known, is destructive of protoplasmic structures, and does not cause them to contract. Under normal circumstances the filaments appear animated by the perpetual tremble of Brownian movement. The contraction commences by the filament becoming shorter and thicker at a number of nearly equidistant points, situated close together near the free end of the filament. The beading spreads rapidly down the filament, which ultimately runs violently together into a ball seated on the top of the gland. Since the movements of the filaments are not governed by forces residing within the gland, but are composed of an essentially contracting substance protruded from the leaf-glands, the only theory which seems capable of connecting the observed facts is that, while the glands were originally only resin-secreting organs, the protoplasm that originally came forth as a necessary con-

comitant of secreted matters, coming into contact with nitrogenous fluids, gradually adapted itself to retain its vitality and take on an absorptive function.

A valuable contribution to microscopical diagnosis in botany is M. Packenham Edgeworth's compact and convenient book on "Pollen," just issued by Hardwicke, London. It is illustrated by twenty-four plates, from drawings by the author, and these afford abundant evidence of the taxonomic importance of pollen; and the book is not only valuable for reference to adepts, but still more extensively interesting to amateurs. The work is exceedingly meritorious and full of valuable facts, and it is creditable to its author and British botany.

M. Henneguy, in a paper recently read before the French Academy, states that *Volvox minor* is diœcious, while the *V. globator* is monœcious. The former is a colony of unicellular algæ, sometimes composed of vegetable cells only, having young colonies in their interiors, sometimes containing male elements (*androgonidia*), situated in the thickness of the gelatinous wall, and sometimes female colonies, containing only *gynogonidia*, or oospheres, in the interior.

The *androgonidia* are formed at the expense of a vegetative cell. The *gynogonidia* likewise spring from a differentiation of a vegetative cellule. The fecundation is effected through the liberation of antheroids by the dissolution of the antheridial wall. These volvoces, male, female, and neuter, seek the light and keep near the surface of the water; but when the female colonies are fecundated, they get away from the surface.

In a paper read lately (September 26) before the Cryptogamic Society of Scotland, Mr. Worthington Smith, F.L.S., explains very fully the structure of the common mushroom. The entire substance is made up of excessively small bladder-like cells, one and a half billion to every ounce of the mushroom's weight. The spores are produced apparently two at a time at the base of each basidium: there are really four, for at the time of dropping off the first two, the last two appear. These spores will, on germination, reproduce the species, but their life is very short. Once germinated, however, and forming the spawn, or mycelium, this has great tenacity of life, and is commonly, if not always, perennial.

In the April number of the *Monthly Microscopical Journal* is an interesting paper, by Professor Giovanni Briosi, of Palermo, on the *phytoptus* of the vine. This disease, producing protuberances, or *cecidii*, on the leaves, oftentimes numerous and confluent, and, in fact, covering the whole leaf —convex on the upper and concave on the under side of the leaves—is due to punctures and irritation produced in the texture by the *acari*, which lodge in the *cecidium* and live on the leaf. The *acari* were termed *phytoptus*, to express that they are really and solely parasites of living plants. They are invisible to the naked eye, and the male cannot be distinguished from the female with certainty. They have but four legs, though Landois supposed that there were two other (rudimentary) pairs, and that in their complete development they possessed four pairs of legs, like other *acari*. Professor Briosi considers that Landois is mistaken, and that these animals constitute a special genus of *acari* which have only four legs. These *arachnida* possess a most extraordinary tenacity of life, moving the legs twenty-four hours after immersion in glycerine. In the autumn they emigrate from the leaves to nestle under the bracts which cover the winter buds, and they have been found alive in buds which had been exposed shortly before to a cold of —10° Fahr. In the spring, with the swelling of the buds, the animals regain their activity, and lay eggs, which are deposited directly on the young leaves of the developing bud, and the young ones are scarcely born when they find already within reach the food which nourishes them; and the galls, or *cecidii*, appear under the form of small spots, scarcely raised, and of a slightly different color from the rest of the leaf, but readily seen by allowing the sunlight to shine through. Repeated careful pruning of the stems which showed the disease the preceding summer, and cutting off the attacked leaves, will, in Professor Briosi's opinion, in a few years result in the destruction of this unwelcome visitor.

In the *Monthly Microscopical Journal* for November, Dr. Hinds calls attention to the motile protophytes in the leaves of *Hypericum androsæmum* and *H. calycinum*. They are to be found in the minute light-colored punctæ near the margin of the leaf, which are translucent from the absence of chlorophyl. They are extremely active, and not of uni-

form size, and their nature and function are still left in obscurity.

At a recent meeting of the Linnæan Society, Mr. Francis Darwin read an account of some microscopical researches on the glandular bodies on *Acacia spærocephala* and *Cecropia peltata*, serving as food for ants, and first mentioned by Mr. Belt in his "Naturalist in Nicaragua." In *Acacia* were two kinds of glands—(*a*) nectar-secreting glands at the base of the petiole; (*b*) small, flattened, pear-shaped bodies, which tip six or seven of the lowermost leaflets of the bipennate leaves. In *Cecropia* cylindrical bodies are developed in flat cushions at the base of the leaf-stalk. The structures are homologous in kind—cellular protoplasm—and contain oil globules, stores of nutriment which undoubtedly the ants live on.

MICROGEOLOGY AND MINERALOGY.

The anniversary address of H. C. Sorby, President of the Royal Microscopical Society, delivered February 7, is mainly devoted to the application of the microscope to geology. The object-glasses used must be of comparatively small angle, *e. g.*, a one eighth of 75°; large angles are positively detrimental, not only causing the object to be almost, if not quite, invisible, from the absence of any dark outline, but the focal point of such lenses is so near their front surface that it is quite impossible to penetrate sufficiently deep down to see the minute fluid cavities in the centre of grains of sand, or to reach the fine particles lying on the surface of the glass slip below the thickness of balsam necessitated by the presence of large grains of sand.

In a paper read before the Royal Microscopical Society, April 4, 1877, by A. Rénard, on the "Mineralogical Composition and the Microscopical Structure of the Belgian Whetstones," the author states that they owe their excessive hardness to garnet, instead of finely divided quartz, as hitherto supposed; in fact, they contain scarcely any quartz. Thin sections seen by transmitted light show myriads of globular forms so excessively minute that their regular bounding lines and frequently lozenge-shaped faces are not attacked in the polishing process. Sometimes they are gathered together at one point; again, they form lines, or chaplets, or are isolated. These minute rhombo-dodecahedral forms, or globular

crystals, are garnet of the variety called spessartine, which, in its pure form, is a little transparent crystal of a pale-yellow color, so that the union of a great number of infinitely small crystals should produce, when regarded *ensemble*, a yellowish-white tint, which is the prevailing color of the whetstones. Chemical analysis also indicates this manganese garnet, and near the veins of whetstone MM. De Koninck and Davreux discovered beautiful little garnet crystals of spessartine. Another element of the whetstone is schorl, showing under the microscope as minute parallelograms, pale green, blue, or grayish, and dicroscopic; also a prismatic mineral allied to chrysoberyl, and only discernible with high powers. It appears as prisms of a greenish-yellow color, scattered throughout the whetstone sporadically, sometimes ranged in lines, often interlacing and superposed, but maintaining a position the while too regular and constant in its repetition not to be subject to some crystallographic law, the simplest form being geniculated twins, with an angle of 60°. The author concludes, from his examination and microscopical study of this rare rock of Salm and the neighborhood, that the whetstone bands are real layers in the Cambrian formation, deposited in the same way as the adjoining slates, and only metamorphosed in a general way, the mineralogical elements being present from the very beginning of the deposit.

In the July number of the *Monthly Microscopical Journal* is a graceful tribute to Ehrenberg by T. Rupert Jones, who, though finding it impossible to accept most of Ehrenberg's specific, and even generic, determinations, states that the better his work is elucidated and understood, the more will his beautiful and lasting illustrations and his painstaking synoptical registers advance the progress of biology in relation to both the present and the past.

After a careful comparison of all Ehrenberg's figures of fossil *Foraminifera*, Professors W. K. Parker and T. Rupert Jones have stated in the *Ann. and Mag. Nat. Hist.*, series 4, vol. ix., p. 216, etc., that, besides twenty undetermined forms, 138 species and noticeable varieties are shown in the "Mikrogeologie," most of which are living at the present day, and eighty-one of which had been named by other observers. Since the publication of the "Mikrogeologie," two noble memoirs have been published by Ehrenberg, the first in 1872, being the

results of his long-continued methodical researches on the microscopic life of the sea-bottom of all zones, illustrated by twelve beautiful plates. The second, in 1874, is a *résumé* of the marine microscopic fossils, treated of in the *Monatsberichte* and *Abhandlungen* of the Berlin Academy, and in the "Mikrogeologie." Also an account of the Polycystine formations of Barbadoes and of the Nicobar Islands, illustrated by thirty quarto plates. Following these are remarks on the chalk marble of Antrim and white marl of Lubin, with notes on the fresh-water and volcanic materials yielding *Diatomaceæ*, on the economic use of microscopic organisms, and on the systematic classification of *Polycystina.* To few has it been given to gather together before death their gleanings of knowledge, industriously sought for during the midday of working life, and to harvest their sheaves in such noble volumes.

Dr. Cohen, of Heidelberg, finds that the *specks* in the Cape diamonds are sometimes due to crystals of specular iron, the larger faces of which lie parallel to the octahedral face of the diamond.

Dr. Leidy, at a recent meeting of the Philadelphia Academy, stated that the examination of the cut opals from the Querétaro mines, Mexico, shows the brilliant display of colors to be due to reflection from facets one quarter to one millimeter in breadth of irregular polyhedral forms, a sort of mosaic pavement on a basis of amorphous opal, but which are distinctly parallel striate, the striæ changing in direction on the different facets, so that the whole consists of an aggregation of particles, of a striated or finely tubular structure, imbedded in a basis of more amorphous opal, and in polished sections emitting the varied hues for which the precious opal is so much admired, according to the varying fineness of the striæ and their inclination.

ANTHROPOLOGY.

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The definition of a science so comprehensive and so dependent as anthropology must be for a long time provisional. Yet those who are conversant with the progress of this department of knowledge cannot have failed to observe, from year to year, a marked improvement in this regard. The following definitions by distinguished anthropologists will indicate the area of the science as now generally understood. "Anthropology," says De Quatrefages, "is the natural history of man, studied monographically, as a zoologist studies an animal." M. Broca defines it to be "the science which studies the human race in its entirety, in its details, and in its relation to the rest of nature." Dr. Topinard considers anthropology to be "that branch of natural history which treats of man and the races of men."

Still less accurately defined are the subdivisions of the subject; but the analysis best suited to a summary of progress is that which brings together the results of the labors of specialists. As in every scientific inquiry there is a descriptive and a deductive phase, in the study of anthropology each assemblage of facts calls forth discussions as to their bearing upon each other, and upon the science at large. It will be impossible to separate these in the summary, inasmuch as the two usually coexist in the same treatise.

The races to be considered are extinct or extant. The study of extinct races, or archæology, is usually the pursuit of a separate class of scholars. This branch of anthropology will therefore claim our attention first. The investigation of extant races is subdivided for the convenience of specialists, as in the course of lectures delivered in Paris during the last winter under the auspices of the Société d'Anthropologie. The notes in this summary will be arranged somewhat on the same plan, as follows:

1. *Anthropotomy*, including the comparative anatomy of man and of the lower animals; called also *anatomical anthropology*.

2. *Biological Anthropology*, comprehending *somatology* and *comparative psychology*, the former embracing *comparative physiology* and external racial or tribal characteristics.

3. *Ethnical Anthropology*, in which are grouped *ethnography*, or the description of tribes and peoples; *ethnology*, or discussions concerning the races of men; and *demography*, or the application of statistics to anthropological investigations.

4. *Linguistic Anthropology* and *Comparative Philology*.

5. *Cultural Anthropology*, or *comparative culture*, including the treatment of the following subjects: food; dwelling and other domestic structures, and their appurtenances; vessels and household utensils; dress and ornament; implements of war and the chase; implements of industry; means of locomotion; methods of measuring and valuing; æsthetic culture in music, pastime, and art; the family; the community; the government; and religion.

6. *Anthropological Instrumenta*, embracing terminology, apparatus of research, instructions to observers, records of meetings, courses of instruction and lectures, transactions of societies, expositions and congresses, museums, periodicals and published works.

In order to render the references the more accessible, they are arranged, where convenient, under the following geographical divisions: North America, Middle America, South America, Europe, Africa, Asia, Malaysia, Australasia, Polynesia.

ARCHÆOLOGY.

NORTH AMERICA.

Several papers were read before the Congress of Americanists at Luxembourg on the antiquities of Greenland and the primitive habitat of the Eskimos. In the first volume of Powell's "Contributions to American Ethnology" is an elaborate communication, by Mr. Wm. H. Dall, upon Succession in the Shell-heaps of Alaska. The report of F. W. Putnam, the curator of the Peabody Museum, upon his labors during the year is given in the tenth annual report. The following papers upon North American archæology have ap-

peared during the year: An Ancient Implement of Wood from near East Windsor, Conn., E. W. Ellsworth, Smithsonian Rep., 1876; the Dighton Rock Inscription, Charles Race, American Anthropological Association; Palæolithic Implements with reference to Eskimo Occupation of North America, Mr. Berlin, same meeting; the Discovery of Supposed Palæolithic Implements in the Glacial Drift of the Delaware River, C. C. Abbott, Peabody Museum Rep. X.; Exploration of a Mound in Lee County, Va., Lucien Carr, Peabody Museum Rep. X.; Ancient Mica-quarrying in North Carolina, C. D. Smith, Smithsonian Rep., 1876 (some of the blocks detached by the aborigines have sold as high as $200); on Prehistoric Remains in Western North Carolina, Alexis A. Julian, paper before the Academy of Natural Sciences, New York; the Shell-mounds of Florida, F. D. Lente, M.D., in *Semi-Tropical* for March and April (the same subject was discussed by Isaiah Gregor before the State Archæological Association, Ohio, and by A. Ecker in *Archiv für Anthropologie*, parts i., ii.); Cranial Perforations by the Ancient Mound-builders, Henry Gillman, American Association. Papers on the Antiquities of Wisconsin were read before the State Historical Society (in Vol. III. of the *Proceedings*, we have the Ancient Civilization of America, W. L. P. Nicodemus; Report of Committee on Exploration of Mounds near Madison; Copper Tools found within the State of Wisconsin, Professor J. D. Butler. A pamphlet on Prehistoric Wisconsin, illustrated with heliotype plates, has been published by the same author); on Wisconsin Mounds, Moses Strong, Smithsonian Rep., 1876. The Davenport Academy of Natural Science has issued Vol. II., Part I., of *Proceedings*, containing, among other important papers, an illustrated account of Inscribed Tablets found by Rev. J. Gass, and discussions about their authenticity and value, by Dr. Farquharson (the society has erected a building for its meetings and collections). Further papers on the same subject are, Explorations in Southeastern Ohio, Professor B. Andrews, Peabody Museum Rep. X.; Sculptured Rocks and Cup-markings in Ohio and Kentucky, Dr. Daniel Wilson, Toronto, pamphlet; Recent Archæological Discoveries in the American Bottom, Ill., by Henry R. Howland, *Bulletin* of the Buffalo Society of Natural Science, March 2; on the Mound-builders of Illinois, *Western Review*, Nov.; on the Rockfort

Tablet, J. D. Moody; the Mounds on Rock River at Sterling, W. C. Holbrook, *American Naturalist*, Nov.; Aboriginal Pottery at Salt Springs, Ill., G. E. Sellers, *Popular Science Monthly*, Sept.; Ancient Earthworks in Indiana, Professor R. P. Brown, *Western Review*, April; Missouri Mound-builders, Judge West, same journal; the Graves of the Mound-builders in Scott and Mississippi counties, Mo., H. N. Rust, before the American Association; Die Culturvölker Alt-Amerikas, Dr. Gustav Bruhl, Parts I.–IX., Cincinnati; Reports on the West Coast of California, Paul Schumacher, Hayden's *Bulletin*, III., i.; on the same by Dr. H. Yarrow in Lieut. Wheeler's Report for 1876, and by Rev. Stephen Bowers in a manuscript description of a superb collection sent to the National Museum. The surveying parties of Professor Hayden, Major Powell, and Lieut. Wheeler have all paid some attention to the archæology of the regions traversed, and their accounts will be found in the reports of these surveys. The plaster models of cliff-dwellings and pueblos by W. H. Jackson are already world-renowned. The following general discussions are worthy of note:

The Caching of Stone Implements, J. F. Snyder, Smithsonian Rep., 1876; the Early Man of North America, A. R. Grote, *Popular Science Monthly*, March; Supposed Evidence of the Existence of Interglacial American Man, Dr. Daniel Wilson, *Canadian Journal*, Oct.; Burial Customs of the Ancient Tribes of Indians, R. S. Robertson, before the American Association; the Stone Age in America, several papers before the Congress of Americanists; Mound-builders and the Pueblos, the same; American Antiquities, J. C. Heaviside; Aboriginal Shell-money, R. E. Stearns, *American Naturalist*, June; Mound-explorations (short descriptions), Smithsonian Rep., 1876.

MIDDLE AMERICA.

Interesting communications on Mexican archæology are to be found in "Anales del Museo Nacional de Méjico," entregas i., ii.; the paper by Ad. F. Bandelier on Ancient Mexican Warfare, in Peabody Museum Rep. X., is a very important contribution; Dr. Georg Fischer, of Freiburg, who may be called the creator of a department of anthropology, contributes to *Archiv*, Heft 3, an illustrated paper on Mineralogy as the Handmaid of Archæology, with special reference to

Mexican Sculptures; in the *Proceedings* of the American Antiquarian Society, 1876, will be found a detailed description of Explorations in Yucatan, conducted by Dr. Le Plongeon, accompanied by his wife. The Smithsonian Institution has received, and will soon publish, a manuscript by Dr. Habel on the Bass-reliefs of Santa Lucia Cosumahualpa, in Guatemala. Hon. Geo. Williamson contributes to the Smithsonian Rep., 1876, a paper on Antiquities in Guatemala. In the same volume will be found an illustrated article on the Latimer Collection in the National Museum from Porto Rico. The Stone Implements are further explained by objects from Turk's and Caicos Islands, sent by Professor Gabb, and Messrs. Gibbs, Brace, Frith, and Murphy. Mr. A. Ober has been engaged during the year in collecting for the National Museum over the ancient Carib area.

SOUTH AMERICA.

In a work entitled "Archives du Muséum National de Rio Janeiro," vol. i., 1876, are the following archæological papers: La Situation, etc., des Sambaques du Brésil, Ch. Wiener; Rémarques sur des Tangas en Terre Cuite de l'Île de Marajo, Ch. F. Hartt; Les Races Indigènes de Brésil, Drs. Lacorda and Peixoto. In the *Bulletin* of the Société d'Anthropologie, 1876, p. 359, Dr. Broca describes a series of crania from Bogota. Professor Orton, while prosecuting his examination of the antiquities of Peru, died near Cuzco (*N. Y. Tribune*, Oct. 20). The late work of the Hon. E. G. Squier on the antiquities of Peru will for some time to come be the classic upon this subject. Dr. F. P. Moreno, whose researches in Patagonia are partially sketched in the *Geographical Magazine*, No. 8, has been very fortunate in discovering the skulls of an ancient race in that country.

EUROPE.

Mr. Pengelly's opening address before the geological section of the British Association was upon Cave Explorations in the south of England, *American Journal*, vol. xiv., p. 299 and 387. At the same meeting excursions were made to the celebrated caves in the vicinity. About thirty papers on anthropological subjects were offered, the great majority of them being archæological. The proceedings of the Anthro-

pological Institute are reported weekly in the *Athenæum*, the *Academy*, and *Nature*. The Glasgow Lecture Society has published Mr. Pengelly's lecture on Kent's Cavern. Attention is called to the following papers on British archæology: Notes on the Barrows and Bone Caves of Derbyshire, Rooke Pennington, *Macmillan's Magazine;* Man and the Glacial Period, Thomas Belt, *Popular Science Monthly*, Nov.; Prehistoric Europe, James Geikie, Dalby and Isbister; Is Man Tertiary? Professor Mantovani, *Geological Magazine;* Ancient Monuments, Sir J. Lubbock, *Nineteenth Century;* Flint Implements, Capt. C. Cooper King, *Popular Science Monthly*, No. 4; Caves and their Occupants, Rev. J. M. Mello, *ibid.*, and in *Quarterly Journal of the Geological Society*, Aug., 1877. The most notable event in England for archæologists during the past year was a discussion, before the Anthropological Institute, upon the Present State of the Evidence as to the Antiquity of Man. The debate was participated in by Messrs. Evans, Hughes, Dawkins, and Tiddemann. Through the press Messrs. Belt, Skertchly, Geikie, and Hughes gave their opinions on the same subject (*Nature*, May 24, 31; June 7, 14, 21, 28; July 5; *Athenæum*, May 5; *Journal of the Anthropological Institute*, Nov.).

In *Matériaux*, No. 12, 1876, M. Mortillet gives a table representing the archæological epochs of France, as elucidated in his lectures, which formed a portion of the "Cours d'Anthropologie." The same savant read a communication before the Société d'Anthropologie entitled "Divisions des Alluvions Quaternaires" (*Bulletin*, 1877, p. 48). At the French Association several archæological papers were read. The meeting is well reported in the *Revue Scientifique*. M. Broca's presidential address on the Fossil Races of Western Europe is given in *Nature*, Aug. 30. Ernest Chantre has published at Lyons Parts I., II., III. of the "Age of Bronze in France," a beautifully illustrated work. James Milne is the author of a work upon Excavations in Karnak, published by D. Douglas, Edinburgh. In the *Dublin Review* for April is an article upon Primitive Man in the Somme Valley.

Upon Scandinavian archæology we notice "The Influence of Classic Industry upon the Civilization of the North," C. Engelhardt, *Matériaux*, No. 2, 1877; "Illustrated Guide-book to the Museum of Antiquities of the North," same author;

"Antiquités du Nord Finno-Ougrien," J. R. Aspelin, *Revue de la Société d'Archéologie Suédoise*, I., II.; *Matériaux*, No. 1.

Germany, that has furnished so many distinguished students of archæology, has not proved a fertile field for the explorer. Dr. Gross presented at the German Anthropological Association Nephrite Implements from Lake Biel, which raised a discussion as to their importation from China. *Archiv für Anthropologie*, with the *Correspondenzblatt* and *Zeitschrift für Ethnologie*, are the authorized media of communication. The Bavarian branch of the German Association has issued several beautifully illustrated numbers of *Beiträge zur Anth. u. Urgesch. Bayerns.* *Correspondenzblatt*, Nos. 9 and 10, contains a full report of the general meeting of the Deutsche Anthropologische Gesellschaft.

Upon Italian archæology we have noticed: A Prehistoric City in Tuscany, R. Pullan, *Academy*, July 1; On the Origin of Terramares, *Archivio*, vol. iv., Nos. 3 and 4; "Gli Scavi della Certosa di Bologna," reviewed in *Matériaux*, No. 1; Sculptures sur les Bords des Lacs de Merveilles, *Matériaux*, No. 8; Bibliographie Italienne, *Matériaux*, Nos. 3 and 4. *Archivio per l'Antropologia*, Florence, continues to be the organ of the Italian archæologists; but it is hard to get a view of it on this side of the Atlantic.

Illustrated notices of the Congress at Buda-Pesth, and on the archæology of the Austro-Hungarian Empire, are to be found in *Matériaux*, Nos. 2, 4, 5, and 7, by E. Chantre; in Smithsonian Rep., 1876, by F. Romer; in *Bulletin* of the Société d'Anthropologie, 1876; in *Proceedings* of the French Association, 1877; in *Mittheilungen der Anthropologischen Gesellschaft in Wien*, 1877; and in *Archiv für Anthropologie*, 1877, parts i., ii.

Preparations are making for an archæological exhibition at Moscow in 1878. The Royal Archæological Commission has been prosecuting extensive researches near Kertch and elsewhere for the exhibition (*Mittheilungen der Anthropologischen Gesellschaft in Wien*, Nos. 4 and 5). Von C. Grewinck, in Dorpat, publishes his work "Zur Archäologie des Balticum und Russlands;" see also *Archiv*, vol. x., articles vii. and xviii. The Kourganes of the province of St. Petersburg are described by M. Maïnoff, *Matériaux*, No. 8. Murray, of London, and the Harpers, of New York, publish General Di Cesnola's magnificent work on Cyprus. The Scribners have

brought out an edition of Schliemann's "Ancient Mycenæ." Attention is called to the following papers of general import: Amber, etc., Dr. A. V. Bastelaer, *Matériaux*, No. 7; M. Franks, *ibid.*, 1876, No. 11; C. V. Baer, *Archiv*, vol. ix., part iv.; Mortillet, *Bulletin* of the Société d'Anthropologie, 1876, No. 59; Genthe, Lindenschmidt, and Hartmann in *Archiv*, 1877, Nos. 1 and 2; Dr. Heinrich Wankel, *Mittheilungen der Anthropologischen Gesellschaft in Wien;* Die Mineralogie als Hülfswissenschaft für Archäologie, G. Fischer, *Archiv*, part iii.; Prehistoric Uses of Iron and Steel, St. J. Day, *Athenæum*, Sept. 2; the Fauna and Flora of Prehistoric Times, Professor Rolleston, British Association, and Woldrich in *Mittheilungen der Anthropologischen Gesellschaft in Wien*, Nos. 4 and 5, 1877; Modern Excavations, J. P. Mahaffy, *Contemporary Review*, April, 1877; Batons of Command, L. Pigorini, *Matériaux*, No. 2; M. Mortillet's Classification, de Neuville, *Matériaux*, Nos. 3 and 4; The Antiquity of Man, Carl Vogt, *Revue Scientifique*, May 5 and 12; S. R. Patteson, *Journal Victoria Institute*, No. 10; Oppert in *Nachrichten der Königl. Gesellschaft der Wissenschaften zu Göttingen*, Nov. 10, 1877; Quatrefages, *Revue Scientifique*, Feb. 3; De Marichard and M. Broca at the French Association; "L'Homme Fossile en Europe," Le Hon, new edition by M. Dupont; Trépanation, De Mortillet, *Matériaux*, No. 4, and Dr. Wankel in *Mittheilungen der Anthropologischen Gesellschaft in Wien*, Nos. 4 and 5; Non-sepulchral Monuments, J. Walhouse, *Nature*, March 8; Kitchen-middens, W. Laws, Anthropological Institute, Dec. 11, 1876; Accumulations of Silex, M. Puligny, French Association; Primitive Agriculture, Miss A. W. Buckland, Anthropological Institute, Aug.

AFRICA.

M. Hamy read a paper before the French Association on the Stone Age among the Negro Races. Mr. George Gibbs, of Turk's Island, in a letter to the Smithsonian Institution, relates a conversation with some negroes wrecked on that island, in which they recognized some celts shown them as similar to those regarded as thunder-stones in their country.

ASIA.

J. T. Wood's "Discoveries at Ephesus" is published by Longmans. R. B. Martin reported to the London Anthropo-

logical Institute, May 1, the discovery of a kitchen-midden at Smyrna. Professor Hitchcock gave an account of the American Palestine Exploration Society before the John Hopkins University, May 1. The same subject was discussed by the Rev. Selah Merrill before the American Geographical Society. A German society for exploring Palestine has been organized by Dr. Zimmermann, of Basle, and others. The *Transactions* of the Society of Biblical Archæology have reached the tenth volume. Mr. Boscawen describes the discovery of a Babylonian Calendar in *Academy*, Nov. 17. The Society for the Promotion of Christian Knowledge is publishing a series entitled "Ancient History from the Monuments." Bertram Hartshorne read a paper before the British Association on the Ancient People of Ceylon. Dr. Foreman publishes in the Smithsonian Rep., 1876, a translation of Blondel's work on "Jade-working among the Chinese." In *Matériaux*, No. 2, M. Moura discusses the Age of Stone in Indo-China. The archæologist who wishes to study the antiquities of India must refer to the *Journal* of the Royal Asiatic Society, with its branches in India; *Zeitschrift der Morgenländischen Gesellschaft; Journal Asiatique;* Trübner's *American and Oriental Record*, and the *Indian Antiquary*, London.

Athenæum, July 28, refers to Stone Circles in Australia.

ETHNOLOGY.

ANATOMY, PHYSIOLOGY, AND PSYCHOLOGY.

Lucien Carr, in the tenth annual report of the Peabody Museum, gives the measurements of the skulls received during the year. T. O. Summers read before the American Association a paper on the Skull of a Comanche. At the British Association Professor Rolleston spoke of the Rationale of Brachycephaly and Dolichocephaly, and upon Artificial Deformation of the Head. At the same meeting Mr. Sorby discussed the coloring matter of the hair. Professor Flower delivered a course of lectures before the Royal College of Surgeons on the Comparative Anatomy of Man. In the *Journal* of the Anthropological Institute, Professor Busk presents a paper on a Collection of Skulls from Mallicollo and Vanikoro. At the meeting of the Institute, March 22, Dr. Clapham made

a communication on Brain-weight of the Chinese and Pelew-Islanders. In *Abhandl. der Königl. Akad.*, Berlin, 1876, Professor Virchow has a valuable paper on the Physical Characteristics of the Germans. In the *Bulletin* of the Société d'Anthropologie, 1876, p. 23, M. Roujou discusses the proportions of the Humerus and Femur. In the same volume is a criticism of the Parietal Angle of De Quatrefages by M. Topinard. At the French Association M. Parrot read a paper on Cranial Deformations occasioned by Hereditary Syphilis. The paper awakened a learned discussion by several anthropologists present. Dr. Gildemeister, *Archiv*, parts i., ii., advocates the adoption of a system of cranial measurement to be settled by common consent. Dr. A. Ecker contributes to *Archiv*, part iii., an illustrated paper upon Cranio-cerebral Topography.

Governor Bross read a paper before the American Association entitled "All Life Conditionally Immortal." Revised editions of George H. Lewes's "Physical Basis of Mind" and Dr. Maudsley's "Physiology of the Mind" have appeared during the year. In the *Revue Scientifique* Fr. Paulhan attempts to establish a physical basis of sensibility in an article entitled "Le Plaisir et la Douleur." Charles Darwin contributes to *Mind*, for July, a Biographical Sketch of an Infant. Albert J. Mott read before the Literary and Philosophical Society, Liverpool, a review of "Haeckel's History of Creation," characterizing it as an attempt to dogmatize where nothing is known. Additional contributions to the subject are the following: "The Struggle of Life," Arthur Nichols, Longmans (see *Nature*, Dec. 7, 1876); Sur la Taille, etc., M. Topinard, *Bulletin* of the Société d'Anthropologie, 1866, p. 410; "Anthropologie Zoologique et Biologique," Broca, Reinwald, and Co.; Méthode de Biologie Humaine, Delauney, *Bulletin* of the Société d'Anthropologie, 1876, p. 586; Professor Haeckel's Address before the German Association on the Evolution Theory in Relation to Science in General; The Influence of Civilization on the Duration of Life, C. T. Lewis, in the *Sanitarian;* Evolution of Man, Rev. J. F. Blake, Sunday Lecture Society, Jan.; Comparison of the Index and Ring Fingers, Francis Galton, *Nature*, Sept. 20; on the Physiological Effects of a very Warm Climate, Dr. O. Loew, Wheeler's Rep., 1876; on Labor and Longevity, R. B. Carter, Sunday

Lecture Society, Feb. 11; Animal Depravity, *Popular Science Monthly*, Dec. (from *Quarterly Journal of Science*).

ETHNOGRAPHY.

North America.

The Migrations of the Eskimos, Dr. J. Rae, a paper before the Anthropological Institute, April 24, 1877; Rink's Greenland reviewed in *Nature*, Nov. 22; The Peopling of America, A. R. Grote, *American Naturalist*, April; Die Indianer Canadas, *Globus*, xxxii., 1877; the American Indians of the Northwest, H. C. Carrington, American Association; Are the Indians Dying Out? S. N. Clark, Bureau of Education, Washington (the same theme was discussed by Col. Garrick Mallery at the American Association); The Sioux of Dakota, Col. A. G. Brackett, Smithsonian Rep., 1876; Centennial Mission to the Indians, Stephen Powers, Smithsonian Rep., 1876 (the same author will be the principal contributor to Powell's "Contributions to American Ethnology," vol. iii.); Ancient and Modern Pueblo Tribes, E. A. Barber, *American Naturalist*, Oct.; An Account of the Nez Percés, Col. Mallery, *Nation*, July 12 and Aug. 2; Location of Indian Tribes from Old Maps, S. D. Peet, American Anthropological Association; Missionary Excerpta, Dr. Dalrymple, Baltimore; The Twana Indians, Rev. M. Eels, Hayden's *Bulletin;* Ethnology of Southern California, O. Loew, in Wheeler's Rep., 1876; The Tribes of the Alaskan Peninsula, W. H. Dall, Powell's "Contributions to American Ethnology," vol. i.; Ethnography, etc., of the Hidatsas, Washington Matthews in Hayden's "Miscellaneous Publications;" Champlain's Expedition against the Hurons, *Magazine of American History;* the Indian Systems of Canada and the United States, Col. Mallery, *Nation*, Sept. 6; Descriptive Catalogue of Photographs of North American Indians, W. H. Jackson, Hayden's "Miscellaneous Publications," 1877. Mr. Clarke Mills has prepared for the National Museum sixty casts of the heads of pure-blooded Indians, of different tribes, confined as prisoners of war at St. Augustine, Florida.

South America.

The Zapateros of Ecuador, A. Simpson, British Association; The Tribes of British Guiana, W. Harper, Anthropo-

logical Institute, Nov. 2, 1876; Das Land der Yukararer, etc., Von Holten, *Zeitschrift*, No. 2, 1877; "Pioneering in Brazil," T. P. Bigg, Murray, London; Ueber die Eingeborenen von Chiloe, L. Mark, *Zeitschrift für Ethnologie*, No. 3, 1877; The Fuegians, M. du Val Dailly, *Bulletin* of the Société d'Anthropologie, 1876, part iii.

Europe.

Ethnology of the Scottish Highlands, Hector MacLean, Anthropological Institute, Aug.; The Old Gaelic Culture, *Westminster Review*, July; The Ethnology of West Cornwall, Rev. Lach Szerma, British Association; "Los Aborigénes Ibéricos," etc., Francisco M. Tubino, Madrid; "The Cagots and Gypsies of France and Spain," V. de Rochas, reviewed by E. B. Tylor, *Academy*, May 5. In the *Bulletin* of the Société d'Anthropologie, 1876, pp. 100, 128, 131, will be found Discussions by MM. Bertrand and Lagneau upon the Celts; the Ethnology of Germany, H. H. Howorth, Anthropological Institute, Dec. 9, 1876; Zur Völkerbewegung in Mitteleuropa, G. Mehlis, *Das Ausland*, May 28, June 11, and in subsequent but not consecutive numbers. The "Lithuanian Provinces," etc., M. Koutznetzoff, reviewed in the *Bulletin* of the Société d'Anthropologie, No. 165, 1876; "Die Arier," Theodor Pösche, Jena, Costenoble; The Magyars, Hyde Clarke, *Journal* of the Anthropological Institute, March 13, 1877 (the same subject, by M. Hunfalvy, *Ausland*); The Laplanders, Von der Horck, Anthropological Institute, 1877; The Early Inhabitants of Mycenæ, Dr. Phene, British Association. The works on Russian and Turkish Ethnology are legion. Attention is called on this point to the following titles: Petermann's *Mittheilungen*, I., 1877; "Russia," D. Mackenzie Wallace; The Bulgarians, Dr. Beddoe, British Association; "Montenegro," Rev. Dr. Denton, Dalby and Isbister; Slavonic Races, *Fraser's Magazine*, Sept.; "Travels in Slavonic Provinces," Mackenzie and Irby, Dalby and Isbister; Les Races, etc., dans l'Armée Russe, *Revue Scientifique*, July; The Turkish Question, *Westminster Review*, Jan. 1; Turkey and Russia, *Edinburgh Review*, Jan.; Races of the Danube, John Fiske, *Atlantic Monthly*, April; review of works in *Westminster Review*, April; "History of Ottoman Turks," Sir Edward Creasy, Bentley & Son; Turkey, *London Quarterly*, April; Pruyssenaere's

"Reisen," *Mittheilungen*, Ergänzungshefte 50, 51. Trübner's Catalogue contains many additional titles.

Africa.

"Upper Egypt," C. B. Klunziger, Blackie & Sons, London; "The Negro Races of Africa," Fred. Müller, "Grundriss der Sprachwissenschaft," vol. i.; "Africa Unveiled," Rev. H. Rowley, Society for the Promotion of Christian Knowledge; "Die Nigritier," Dr. Robt. Hartmann, Berlin, treats of North-eastern Africa; "The Cradle of the Blue Nile," E. A. de Corson, Murray; The People of Southern Africa, M. de Jouvencal, *Bulletin* of the Société d'Anthropologie, 1876, pp. 350, 385; "The Races of the Chad Basin" in *Nature*, April 26, review of Dr. Nachtigall's work; Stanley's Letters on his Adventures among the Tribes of the Lualaba-Congo, *New York Herald*, Oct. 9 and 10; "Across Africa," Cameron, Dalby and Isbister; "Zulu Folk-lore," Calloway, *Academy*, Nov. 17.

Asia.

The Quetta and the Afghans, Major Raverty, *Geographical Magazine*, vol. xi., p. 288; "The Country of Beloochistan," A. W. Hughes, Geo. Bell and Sons, London. "The People of the Upper Oxus" is the title of an elaborate ethnological memoir promised by the Russian Geographical Society. Vol. IV., Part I., of Wheeler's "India" is announced. For further works on India, Trübner's Catalogue must be consulted. "The History of China," Venerable J. H. Gray, Macmillan.

Oceanica.

On the Javanese, A. H. Kiehl, *Journal* of the Anthropological Institute, vol. vi., p. 346; The Malays and Polynesians, Rev. S. J. Whitmee, Anthropological Institute, Nov. 27; "Origin and Migration of the Polynesian Nations," John D. Lang, Sampson Low and Co.; Our Knowledge of the Nicobarians, W. L. Distant, *Journal* of the Anthropological Institute, vol. vi., p. 209; New Guinea and Polynesia, *London Quarterly*, July. The researches of D'Albertis and Beccari in New Guinea are reviewed in the *Archivio* for 1877, parts ii. and iii., by Mantegazza. This paper, illustrated by many plates, is the best *résumé* of the subject lately published. "Migrations en Polynésie," A. de Quatrefages, Paris, Martinet; In-

habitants of the Admiralty Islands, H. N. Moseley, Anthropological Institute, Jan. 9; the Natives of Socotra, J. Hunter, British Association; Old and New Zealand, *Academy*, Nov. 18; The South Sea Islanders, W. L. Rankin, Anthropological Institute, Jan., 1877; The Dying-out of Polynesian Races, Mr. Wedderburn, *Fortnightly;* The Polynesian Race, Abraham Fornander, vol. iii., *English and Foreign Phil. Library.*

General Discussions.

"The Origin of Nations," George Rawlinson, Scribner's reprint; L'Espèce Humaine, De Quatrefages, *Revue Scientifique*, March 24; Negro and White Races, C. H. Fort, *American Journal of Obstetrics*, April.

DEMOGRAPHY.

Mr. Francis Galton, who is almost the creator of this department of ethnology, delivered an address before the Department of Anthropology, Section D, British Association, on the Application of Statistics to Anthropological Researches, *American Journal*, vol. xiv., p. 265. The same author read a paper before the Royal Institution, Feb. 9, on the Typical Laws of Heredity. Further communications are: Démographie de la Seine Inférieure, Dr. Bertillon, French Association; The Growth of Children, Professor H. P. Bowditch, State Board of Health, Mass. Behm and Wagner's "Bevölkerung der Erde" forms the forty-ninth Supplement to Petermann's *Mittheilungen*. Color of the Hair, Eyes, and Skin of German Children, Professor Virchow, German Anthropological Society.

PHILOLOGY.

America.

Major J. W. Powell, now in charge of all the American linguistic material collected by the Smithsonian Institution, has largely added thereto from other sources; and, in order to make thorough work, has issued a pamphlet of instructions to collectors, entitled "Introduction to the Study of Indian Languages, with Words, Phrases, and Sentences to be Collected." The first volume of Major Powell's "Contributions to American Ethnology" contains the Niskwally Gram-

mar and Dictionary of George Gibbs. Further contributions to American linguistic science are the following: Indian Names of Places on Long Island Derived from Esculent and Medical Roots, J. Hammond Trumbull, *Magazine of American History;* The Tonkawa Languages, Albert S. Gatschett, American Philological Society (papers from the same author will be found in the *Magazine of American History*, March, 1877, in Wheeler's Rep. for 1876, and in a pamphlet in German upon the Idioms Spoken in the Southwest of the United States); On the Utah Dialects, Edwin A. Barber, Hayden's *Bulletin*, vol. iii., No. 3; Hidatsa Grammar and Vocabulary, Washington Matthews, Hayden's Miscellaneous Publications; The Red Man Gauged by his Speech, E. Jacker, *Catholic Review*, April; American Indian Philology and Hieroglyphics, Congress of Americanists, and at the American Philological Association, Baltimore, July 6.

Middle and South America.

"The Indigenous Languages of Mexico," Francisco Pimentel, Mexico, 3 vols.; The Language of Nahuatl, M. Lucien Adam, *Revue Linguistique*, Jan.; The Tupi Language, P. Gaffarel, same number; The Use of Phonetic Characters by the Peruvians, Gustav Bruehl, State Archæological Association, Ohio.

Europe.

Transactions of the Philological Society, London, 1877, part i., contains the President's address, and a review of the great families of languages by specialists. In the *Academy*, Jan. 13, attention is called to a series of articles in the *Hermathena* on the Ogham alphabet. The following papers may be examined with profit: On the English Names of Wild Flowers and Plants, Rev. W. Tuckwell, *Nature*, Aug. 30; Marks Found in the Chalk of Cissbury, Park Harrison, *Journal* of the Anthropological Institute, Jan.; The Etruscan Language, Rev. I. Taylor, *Journal* of the Victoria Institute, vol. x., and in *Fraser's Magazine*, March; On the Name Mediterranean, F. J. Bell, *Journal* of the Anthropological Institute, Jan. 17; Das Problem über den Ursprung der Sprache, O. Caspari, *Ausland*, Nos. 47, 48, 49. The annual meeting of German Philologists and Teachers, Wiesbaden, Sept. 26–28.

Asia.

The Origin of Semitic Languages, Rev. I. Taylor, *Academy*, Aug. 4. For discussions upon the languages of Southern Asia reference must be made to the eminent journals mentioned under Asiatic ethnology.

Oceanica.

Under the supervision of Rev. J. S. Whitmee a series of Polynesian grammars and dictionaries is being compiled.

General Discussions.

The Functions of the Uvula, Dr. Rumbold, *Western Review*, vol. i., No. 1, from *St. Louis Journal;* The Physiology of Language, E. B. Tylor, London Institute, Jan. 22 and 29; the History of Alphabets, Rev. Isaac Taylor, Victoria Institute, June 18; Races and Languages, E. H. Freeman, *Contemporary Review*, May; in *Ausland*, May 7, is a review of Müller's "Grundriss der Sprachwissenschaft;" *Academy*, Aug. 25, contains a review of Hovelacque's "Linguistics," by Rev. A. H. Sayce.

CULTURE.

Aliment.

On the Stimulants of Ancient and Modern Savages, Miss A. W. Buckland, British Association.

Edifices.

Indian Fort Dwellings, Dr. W. E. Doyle, Smithsonian Rep., 1876.

Vessels.

The works of Prime and Elliott on Pottery are praiseworthy additions to our literature on the subject: a review of Prime by F. W. Putnam will be found in *The Nation*, Jan. 3, 1878.

Implements.

Classification of Arrowheads, W. J. Knowles, Anthropological Institute, Dec. 11, 1876; Perforations of Stone, Wurmbrand, *Mittheilungen*, Nos. 4 and 5; Flint Cores as Implements, Dr. Gillespie, Anthropological Institute, Jan.; On the Boomerang, A. W. Howitt, *Nature*, Feb. 8; Vegetable Poi-

sons in Samoa, Rev. Thos. Rowell, Linnæan Society, March 15; Obsidian Cutlers of Melos, *Nature*, Feb. 15; Chinese Modes of Fishing, *Popular Science Monthly*, June; Irrigation Works in India, B. Hartshorne, British Association; The Earliest Seat of the Domestication of Animals, V. Frantzius, *Archiv*, parts i., ii.; A New Domestic Dog of the Bronze Period, Woldrich, *Mittheilungen der Anthropologischen Gesellschaft in Wien*, Nos. 4 and 5; Crude and Curious Inventions at the Centennial Exposition, E. H. Knight, *Atlantic Monthly*, March to December.

Valuing.

A Calendar of the Dakota Nations, Col. Garrick Mallery, Hayden's *Bulletin*, vol. iii., No. 1.

Music.

On the Hindoo Octave, R. H. M. Bosanquet, Royal Society, Feb. 8. Mr. Knight's articles named above treated in the first chapters on Musical Instruments.

Sports.

The Horse as an Instrument of Gambling, *Contemporary Review*, Aug.; La Crosse, *Canadian Monthly*, April.

The Family.

"The Knot Tied," Wm. Tegg, published by Tegg and Co., London. The new edition of McLennan's "Primitive Marriage" is reviewed by Lubbock, *Nature*, Dec. 14, 1876; On the Evolution of the Family, Herbert Spencer, *Popular Science Monthly*, several numbers; "Das Kind in Brauch and Sitte der Völker," Dr. Ploss, Stuttgard, 2 vols.; Infanticide, C. A. Fyffe, *Nineteenth Century*, June; English Nursery Tales, W. R. S. Ralston, London Institute, Feb. 22; Turkish Story-books, *Nineteenth Century*, No. 1.

Social Life.

"Meetings and Greetings," Wm. Tegg, London; Aboriginal Funeral Customs, *American Naturalist*, April; Folk Dirges, *Cornhill Magazine*, Aug.; Le Faste Funéraire, *Revue des Deux Mondes*, March and April; Cremation in Sitka, *American Naturalist*, June; Burial of the Dead among the Primitive Aryans, *Matériaux*, vol. ix. Dr. H. C. Yarrow will

prepare an exhaustive memoir on the subject of Aboriginal Burial among the American Indians, and has issued a circular asking for information from all quarters.

Government.

The Origin of Rank, *Living Age*, April 7 (from *Saturday Review*); "Flagellation and Flagellants," Rev. W. Cooper, published in London.

Religion.

Outlines of the Philosophy of the North American Indians, J. W. Powell, American Geographical Society; "Serpent and Siva Worship in Central America," Hyde Clarke, Trübner and Co.; Culture Heroes of the Ancient Americans, J. T. Short, *Appletons' Journal*, March; Mythologie, etc., des Esquimaux, *Mélusine*, Feb. 20 (the last-named periodical is entirely devoted to comparative mythology); Nagualism, etc., in the United States, *Catholic World*, April; Basque Legends, Dr. Fitzgerald, *Gentleman's Magazine*, Sept., and by W. Webster in a work published by Griffith and Farren (see *Nature*, March 8); Tyrolean Superstitions, Ethel C. Gale, *Lippincott's Magazine*, June; Sicilian Folk-lore, *Cornhill Magazine*, April; Religion and the Great Pyramid, R. A. Proctor, *Fraser's Magazine*, March; An Egyptian Phallus and Hebrew Circumcision, Hermann Welcker, *Archiv*, parts i., ii.; "Mythology among the Hebrews," I. Goldzieher, Longmans; "The Folklore of China," N. B. Denys, Trübner and Co.; New Zealand Myths of Creation, *Journal* of the Anthropological Institute, Jan.; "Magic among the Chaldeans," F. Lenormant, Maisonneuve; "Les Dieux de Babylone et de l'Assyrie," *id.;* Traditions Assyriennes, *Ann. Ph. Chrétienne*, Jan.; "Sur la Légende du Boudha," E. Senart, E. Leroux; Symbolism of the Features, J. W. Jackson, *Phrenological Journal*, March 6; "Finger-ring Lore," Wm. Jones, reviewed in *Academy*, Nov. 18; Mesmerism, etc., W. B. Carpenter, *Popular Science Monthly*, June; Demonolatry, etc., R. C. Caldwell, *Contemporary Review;* On Demonology, M. D. Conway, Sunday Lecture Society; Myths, R. A. Proctor, *Belgravia*, Sept.; The Myths and Marvels of Astronomy, same, *Putnam's Magazine;* Astronomical Myths, John P. Blake, from Flammarion; La Nomenclature des Légendes Anciennes, M. Daleau, French Association; Zur Geschichte der Religion, *Ausland*, Feb. 5; The Rationale

of Mythology, *Cornhill Magazine*, April; Discussion upon "Religiosité," *Bulletin* of the Société d'Anthropologie, 1877, pp. 30 and 56; L'Anthropophagie, *Revue Scientifique*, No. 10; Trépanation, *Bulletin* of the Société d'Anthropologie, 1876, pp. 551, 572; 1877, p. 12.

General Treatises.

Part V. of "Descriptive Sociology," Herbert Spencer; "Principles of Sociology," vol. i., same, reviewed by E. B. Tylor in *Mind*, April; Dr. Mehlis's work on the "Sociology of the Inca Empire," reviewed in *Ausland* for March; "Ancient Society," L. H. Morgan, Henry Holt and Co. A new edition of Von Hellwald's "Culturgeschichte" has brought the subject down to the present time.

INSTRUMENTALITIES.

APPARATUS.

An Archæological Exchange Club has been organized by Rev. S. D. Peet, Ashtabula, O. Professor Flower, in his lectures on the Comparative Anatomy of Man, drew attention to a stereograph invented by M. Broca for the accurate delineation of crania, etc.

TERMINOLOGY.

A discussion upon the words anthropology, ethnology, and ethnography, *Bulletin* of the Société d'Anthropologie, 1876, pp. 199, 298, 375; by M. Broca in his opening address before the Cours d'Anthropologie, Paris; and by Topinard in the introduction to his "Anthropologie." In the *Journal* of the Anthropological Institute Wm. L. Distant discusses the propriety of the use of the word religion by anthropologists.

MEETINGS.

American Association, Nashville, Aug. 29; American Anthropological Association, Cincinnati, Sept. 5 and 6; American Philological Association, July 6; American Geographical Society; State Archæological Association, Ohio, Aug.; State Archæological Association, Indiana, Sept. 12; British Association, Plymouth, Aug. 15; French Association, Havre, Aug. 23; Congrès des Américanistes, Luxembourg, Sept. 10;

Congrès Archéologique de France, Senlis, May 28; German Anthropological Association, Constance, Sept. 24; German Association of Naturalists and Physicians, Munich, Sept. 17; Russian Archæological Association, Kazan, Aug. 12.

TRANSACTIONS.

Davenport Academy, vol. ii., part i.; Wisconsin Academy of Natural Science; Smithsonian Rep., 1876; Peabody Museum Rep., vol. x.; *Journal* of the Victoria Institute, vols. x., xi.; *Journal* of the Anthropological Institute, in parts to Nov.; *Bulletin* of the Société d'Anthropologie; *Archiv für Anthropologie; Zeitschrift; Mittheilungen der Anthropologishen Gesellschaft in Wien; Beiträge zur Anthropologie Bayerns*, Nos. 1, 2, 3, 4; *Annales de l'Académie Eth. de la Gironde.*

LECTURES.

Course on Prehistoric Archæology, Syracuse University, W. de Hass; Cours d'Anthropologie, Paris, MM. Broca, Topinard, Hamy, Bertillon, Hovelacque, Mortillet, and Dally.

MUSEUMS.

The Smithsonian Institution has issued a circular in order to ascertain the location of all aboriginal remains and of every public and private anthropological collection in America. *Beilage zu No.* 1 *des Correspondenzblattes*, 1876, contains a catalogue of public and private anthropological museums in Germany and adjoining countries. The anthropological collections of the National Museum were more than doubled in number and value by the Centennial Exhibition. The president's address at the last annual meeting of the Anthropological Institute was a *résumé* of the society's work during the year. An Ethnographical Museum has been opened at Helsingfors, Finland. The Museum für Völkerkunde, Leipsic, has issued its fourth annual statement.

PERIODICALS AND BIBLIOGRAPHY.

Professor W. Koner, in *Zeitschrift für Ethnologie*, Dec., 1877, gives a list of 2000 ethnological and anthropological treatises for 1876. Sabin's *Bibliotheca Americana* has reached its fiftieth number with the word Jamaica. The same publisher has issued "A Bibliography of Bibliographies."

ZOOLOGY.

By Dr. A. S. PACKARD, Jr.,*
Director of the Peabody Academy of Science, Salem, Mass.

GENERAL ZOOLOGY.

Zoological science has advanced during the past year, not only in systematic and biological directions, but also in the more difficult fields of histology, embryology, and physiology.

Treatises.

Among general works are those of Pagenstecher and Jäger, and Huxley's "Manual of the Invertebrates."

Explorations and Researches.

Explorations have been carried on in North America by Cope, Goode, Scudder, Packard, Boucard, Jordan, Verrill, Streets, and others, and in South America by Professor Orton; while Professor Morse has made valuable observations on the lower animals of Japan, and European explorers have been as active in the Old World.

The United States Fish Commission has made valuable discoveries off the coasts of Massachusetts and Nova Scotia, besides prosecuting its work in our inland waters.

In March, Congress passed an appropriation providing for a commission of three skilled entomologists to report upon the depredations of the Rocky Mountain locust, and the best practicable method of preventing or guarding against their recurrence. The commission was attached to Hayden's United States Geological Survey, and consisted of Messrs. C. V. Riley, A. S. Packard, Jr., and Cyrus Thomas. Explorations have been carried on between the ninety-fourth meridian and the Pacific coast, and two bulletins of immediate practical interest issued, while a report of the summer's work is nearly ready.

* The chapter on the vertebrates has been furnished by Professor Theodore Gill, of Washington, D. C.

Several volumes on zoology have been issued by the United States Geological Survey, conducted by Professor F. V. Hayden. Of these the most important are: "Monographs of North American Rodentia," by Elliott Coues and Joel Asaph Allen; published as one of the quarto series of the United States Geological Survey of the Territories, F. V. Hayden in charge: Washington, 1877. It contains eleven monographs—five by Dr. Coues and six by Mr. Allen, with appendix. "A Synoptical List of the Fossil Rodentia of North America," by J. A. Allen, and Appendix B. "Material for a Bibliography of North American Mammals," by Theodore Gill and Elliott Coues. The volume is carefully indexed, comprises 1091 pages, and contains five plates illustrative of the skulls of the Muridæ. It is a monumental work upon a single order of mammals.

The volume on Zoology of Lieutenant Wheeler's Survey of the Western Territories, carried on by the United States Engineer Corps, is dated 1875, but has but recently been distributed. It is largely devoted to an enumeration of the birds of the Rocky Mountains, with extended remarks on their habits and distribution by Mr. H. W. Henshaw. The mammals are discussed by Drs. Coues and Yarrow, who also report on the batrachians and reptiles, while the fishes have been worked up by Professor Cope and Dr. Yarrow. Much space and several beautiful plates are devoted to the insects, the following gentlemen presenting reports on the species belonging to the orders of which they have a special knowledge, to wit: E. T. Cresson, Edward Norton, T. L. Mead, W. H. Edwards, R. H. Stretch, R. Osten-Sacken, H. Ulke, P. R. Uhler, Cyrus Thomas, and H. A. Hagen; while Dr. Yarrow reports on the shells, and Professor A. E. Verrill on the leeches.

A bulky report on the vertebrate paleontology of Wheeler's survey, illustrated with many plates, comprises the results of Professor Cope's researches in New Mexico and Colorado during a single season.

After a delay of several years, Captain (now Colonel) Simpson's report of explorations across the Great Basin of the Territory of Utah has appeared, containing a list of birds collected on the expedition, by Professor S. F. Baird, and a finely illustrated report on the fishes by Professor Gill.

Dr. Sachs, who was sent to Venezuela by the Berlin Academy of Science, for the purpose of studying the electric eel in its native haunts, has returned, after an absence of ten months, with a rich store of valuable observations.

Professor E. D. Cope has lately visited the Nickajack Cave, near Chattanooga. The cave is as large as the Mammoth or Wyandotte Cave, and is traversed by a large stream. He found an abundance of a blind craw-fish and several small crustacea, some of them allied to *Cæcidotæa*. He also procured the myriopod *Spirostrephon cavernarum*, a spider with eyes, and a Raphidophora, etc.

The reports upon the biological results of the *Valorous* expedition by Dr. Gwyn Jeffreys and Dr. Carpenter, as well as the Rev. A. M. Norman and others, are contained in the *Proceedings* of the Royal Society of London. The *Valorous* was a store-ship sent out with the recent British polar expedition, and on her return from Disco Island dredged and sounded with most interesting results. Living *Globigerina* were captured on the outward voyage, and "countless numbers of a microscopic mite, which swarmed everywhere, and appeared to be busily engaged in eating the outer layer of the sea-weed, as well as the spawn" of a mollusk and the animal of a polyzoon. Some remarkable brachiopods, a new genus of sea-urchins, new shells and worms, several of which are fossil in Sicily, occurred at depths between one thousand and two thousand fathoms. Thirty-three species of shells were added to the list of Greenland shells, while the lists of Crustacea, Tunicata, Polyzoa, Radiata, etc., were greatly increased, as this is the first time that dredging has been carried on at such depths off the coast of Greenland. Mr. Jeffreys suggests that the marine fauna of Greenland is rather European than American; while Mr. Norman, on the other hand, believes that the fauna of Davis's Strait is American rather than European. It seems to us that the reporters overlook the fact that the polar deep-sea life is neither exclusively American nor European, but *circumpolar*, with features of subordinate importance characterizing each side of the Atlantic. The map showing the ocean bottom of the North Atlantic is of much interest in connection with recent speculations as to the former existence of a Tertiary polar continent connecting Europe and Greenland with America.

The coloring matters of various animals, and especially of deep-sea forms dredged by the *Challenger*, are described by Mr. Moseley in the *Quarterly Journal of Microscopical Science.* During the voyage of the *Challenger* he made a continued series of observations with the spectroscope on the coloring matters of various invertebrate animals. The colors were examined spectroscopically in almost all cases in which an animal presented marked coloration, but usually further attention was only paid in those instances in which a spectrum presenting isolated bands was obtained, such coloring matters being of most immediate interest, because they are able to be readily identified.

Mr. Moseley's remarks, in the same paper, on phosphorescent animals are interesting. Very little, if any, light can penetrate from the surface of the sea to depths such as one thousand or two thousand fathoms. Nevertheless, several facts show that at these depths light of some kind exists. Some deep-sea animals are entirely destitute of the eyes possessed by their shallow-water congeners, and appear, like the blind cave-animals, to rely on touch alone, being provided with specially long antennal hairs or fine rays for the purpose of feeling. Professor Wyville Thomson and Dr. Carpenter have suggested that phosphorescent animals form the source of light in the deep sea. Mr. Moseley seems to adopt this rather absurd view, and he adds that "it seems certain that the deep sea must be lighted here and there by greater or smaller patches of luminous Alcyonarians, with wide intervals, probably, of total darkness intervening. Very possibly the animals with eyes congregate around these sources of light."

A second contribution to our knowledge of the animals of Lake Titicaca, in South America, is a list of the mammals and birds by Mr. J. A. Allen, and of the crustacea by Mr. Walter Faxon. Mr. Garman contributes a number of interesting notes concerning the llama, alpaca, guanaco, and vicuña. Two new birds are described—a *Gallinula* and an *Ibis.*

Under the title of "Scientific Results of the Exploration of Alaska by the Parties under the charge of W. H. Dall," Vol. I., No. 1, Mr. Dall has begun the publication of the results of his researches on the marine animals of the north-

west. The present number contains an introductory note on the marine faunal regions of the North Pacific, and an article on the extrusion of the seminal products in limpets, with remarks on the phylogeny of the *Docoglossa* by Mr. Dall, while a report on the hydroid polypes, illustrated with ten plates, is contributed by Mr. S. F. Clark.

Professor J. B. Steere, of the University of Michigan, has recently returned from an expedition to the Philippine Islands, bringing with him large collections of animals. The birds have been placed in the hands of Mr. R. B. Sharpe, of London, and form one of the most important ornithological collections yet made in that region, containing many novelties.

The last annual report of the German North Sea Commission contains an article by Dr. Kirchenpauer on the *Polyzoa* of the Baltic Sea, one by Dr. Kupffer on the *Tunicata*, and one by Dr. Moebius on the minute *Crustacea*.

Relation of Animals to their Surroundings.

Mr. A. R. Wallace, in his recent address before the Section of Biology of the British Association, draws attention to the connection observed between color and locality. His first example is from tropical Africa, where we find two unrelated groups of butterflies, belonging to two very distinct families (*Nymphalidæ* and *Papilionidæ*), characterized by a prevailing blue-green color not found in any other continent. Again, we have a group of African *Pieridæ* which are white or pale yellow, with a marginal row of bead-like black spots, and in the same country one of the *Lycænidæ* (*Liptena erastus*) is colored so exactly like these that it was at first described as a species of *Pieris*. The resemblance did not seem due to protective mimicry. In South America we have far more striking cases; for in the three sub-families *Danainæ*, *Acræniæ*, and *Heliconiinæ*—all of which are specially protected—we find identical tints and patterns reproduced, often in the greatest detail, each peculiar type of coloration being characteristic of distinct geographical subdivisions of the continent.

But it is in islands that some of the most striking examples of the influence of locality on color occur, and this generally in the direction of paler but sometimes of darker and

more brilliant hues, and often accompanied by an unusual increase of size. Persons who are not acquainted with these and many other facts adduced by Mr. Wallace would, he thinks, hardly realize their importance and significance. He therefore illustrates them by supposing parallel cases to occur among the mammals. "We might have, for example, in Africa the gnus, the elands, and the buffaloes all colored and marked like zebras, stripe for stripe over the whole body exactly corresponding. So the hares, marmots, and squirrels of Europe might be all red, with black feet, while the corresponding species of Central Asia were all yellow, with black heads. In North America we might have raccoons, squirrels, and opossums in parti-colored livery of white and black, so as exactly to resemble the skunk of the same country; while in South America they might be black, with a yellow throat-patch, so as to resemble with equal closeness the tayra of the Brazilian forests."

With birds, however, the case is different, and among them locality exerts a marked influence. One of the most curious cases is that of the parrots of the West Indian Islands and Central America, several of which have white heads or foreheads, occurring in two distinct genera, while none of the more numerous parrots of South America are so colored. The Andaman Islands are equally remarkable, at least six of the peculiar birds differing from their continental allies in being much lighter, and sometimes with a large quantity of pure white in the plumage, exactly corresponding to what occurs among the butterflies. In Celebes we have a swallow-shrike, and a peculiar small crow, allied to the jackdaw, whiter than any of their allies in the surrounding islands. In Timor and Flores we have white-headed pigeons, and a long-tailed fly-catcher almost entirely white. In the small Lord Howe's Island formerly lived a white rail (*Notornis alba*), remarkably contrasting with its allies in the larger islands of New Zealand.

Mr. Wallace has also published an important article on the colors of animals, with criticisms on the theory of sexual selection.

Dimorphism.

In an essay entitled "Antigeny, or Sexual Dimorphism in Butterflies," published by Mr. S. H. Scudder in the *Proceed-*

ings of the American Academy of Arts and Sciences, Boston, the author states that Darwin, in his work on sexual selection, discusses the difference of coloration which frequently distinguishes the sexes of butterflies, and concludes that "the male, as a general rule, is the most beautiful, and departs most from the usual type of coloring of the group to which the species belongs." Mr. Scudder remarks that of the first proposition there is no doubt, but that in the second two distinct elements appear to be confounded, the separation of which he attempts. He suggests the term *antigeny*, signifying opposition or diversity of the sexes, to avoid circumlocution, for there are so many forms of sexual dimorphism that a compound term for the general phenomenon becomes inconvenient. He cites a number of cases of partial antigeny, and concludes that in all these cases it is the female, and never the male, which first departs from the normal type of coloring of the group to which the species belongs. Occasionally the feminine peculiarity has been transmitted to the male, and by this means a new type of coloration established in the group; but Mr. Scudder recalls no case where the male alone departs from the general type of coloring peculiar to the group. This is precisely the opposite conclusion to that which Darwin reached.

Sexual dimorphism is not confined to coloration, but to structural features. The latter is always confined to the males, and in butterflies is mostly confined to the wings and the legs; occasionally it appears in the antennæ, while sometimes it affects the contour of the wings.

Darwin supposes that the various male characteristics have all arisen by natural selection, one of rival males being selected as a mate whose outward charms are greatest. Mr. Scudder brings forward as limiting this notion the fact that the males of many butterflies possess peculiar cells, which he calls *androconia*, and are of great beauty and delicacy, but are hidden among the others. In this respect the theory of sexual selection proposed by Darwin appears to fail just where it should aid us most.

Anatomy and Physiology.

In an account of experiments on the sense organs of insects in the *American Naturalist*, Mr. A. S. Packard, Jr.,

says that of a number of insects of all orders which were deprived of their antennæ, the honey-bee (worker) was more affected than any of the others operated upon. The removal of the antennæ in this insect seemed to show that the sense of hearing may reside in the antennæ, while that of smell has its seat in the palpi (and perhaps the tongue) alone. It would also seem as if the antennal nerves were so continuous with the brain (supraœsophageal ganglia) that they form, as it were, a part of it, their removal at a little distance from their origin producing such a shock to the ganglionic nervous system that the insect acts somewhat like a bird when deprived of the central hemispheres. In an ichneumon the sense of taste appears to be situated in the ends of the palpi. In the butterflies the sense of taste, as well as touch, is situated in the spiral tongue or maxillæ. Spiders on losing their maxillary palpi seemed to be affected much as insects on the loss of their antennæ.

While many of the higher insects, as grasshoppers, katydids, crickets, cicadas, and even moths produce a creaking or stridulating noise by rubbing one part of the body on another, it has hitherto been unsuspected that scorpions have the same faculty. Mr. J. Mason Wood, however, has recently announced the discovery of stridulating organs in the scorpion. After noticing this, while dissecting a specimen, he was able to confirm it by experiments on living examples. By placing two large scorpions face to face on a light metal table and exciting them, they began to beat the air with their palps and simultaneously to emit sounds which were most distinctly audible not only to himself, but also to the bystanders, above the clatter made by the animals in their efforts to get free, and which resembled the noise produced by continuously scraping a piece of silk-woven fabric; or, better still, a stiff toothbrush with one's finger-nails. The apparatus which, as in the *Mygale*, a large spider, is developed on each side of the body, consists of a scraper situated upon the flat outer face of the basal joint of the palp-fingers, and of a rasp on the equally flat and produced inner face of the corresponding joint of the first pair of legs. On separating these appendages from one another, a slightly raised and well-defined large oval area of lighter coloration than the surrounding chitine was to be seen at the very base of

the basal joint of each. These areas constituted respectively the scraper and the rasp: the former was tolerably thickly but regularly beset with stout, conical sharp spinules curved like a tiger's canine, only more towards the points, some of which terminate in a long limp hair; the latter thickly studded with minute tubercles shaped like tops of mushrooms.

It now remains for Mr. Wood or some one else to discover the *ears* of the scorpion; for if they can produce a sound, they must have ears to hear it, and none are as yet known to exist in the *Arachnida.*

In insect anatomy, an elaborate memoir on the so-called ventral vessel of the *Lepidoptera,* with observations on the sympathetic nerve, has been published in Hofmann's *Niederländisches Archiv für Zoologie* (Bd. iii., Heft 2, 1876). The examination of these organs was made in examples of all the families from the *Papilionidæ* to the *Pterophoridæ.*

A memoir on the internal spinning apparatus of Lepidopterous insects, by Helm, appears in Siebold and Kölliker's *Zeitschrift* (vol. xxvi.).

Dr. O. J. B. Wolff has published in the "Nova Acta Acad. Natur. Curios.," vol. xxxviii., Dresden, 1876, a memoir (illustrated with eight plates) on the minute anatomy of bees, with reference especially to the mechanism of the mouth-organs and respiratory organs of the thorax and abdomen.

An elaborate and richly illustrated memoir on the sense-apparatus of the *Orthoptera,* by Dr. V. Graber, appears in the *Transactions* of the Imperial Academy of Science of Vienna.

Dr. C. Chun has studied the structure, development, and physiology of the rectal glands of insects. His memoir, with three plates, is in the *Transactions* of the Frankfort Scientific Society.

Evolution.

Among communications of theoretical interest are articles by Mr. W. H. Dall, "On a Provisional Hypothesis of Saltatory Evolution," and by Dr. W. K. Brooks, entitled "A Provisional Hypothesis of Pangenesis," both published in the *American Naturalist.*

Parthenogenesis.

That fishes and other vertebrates have in two or three observed cases been partially developed without fecundation

is on record. Dr. E. L. Sturtevant, on removing (March 15) some eggs from a pickerel, found that some of the eggs "had evidently developed in the line of the fecundated egg, as the cells were arranged in the form of a curled fish, the line of the back being well defined, the line of the belly and sac poorly or not at all defined, while there was a concentration of cells about the locality of the eye. I cannot say that I saw a young fish, for I did not, but I saw what I considered sufficient to interpret as development to a certain degree without fecundation." The account in full appears in the *American Naturalist* for August; and in a succeeding number Professor W. K. Brooks gives a history of what is known on this subject.

VERTEBRATES.*

Progress in Vertebrate Zoology has been essentially similar to that in past ordinary years. No discovery of a startling character has been made, but the usual activity has been manifested in the search for and description of new species, in the more or less careful elaboration of small groups and faunas, and in anatomical studies of special forms. We here confine ourselves to notices of a few contributions which have a general interest, or relate to the North American fauna.

The Limits of the Branch of Vertebrates and its Classes.

Until quite recently, and since Cuvier first established the "embranchement" of Vertebrates, the group so designated was accepted without hesitation with the limits originally given to it. Charles Bonaparte, the Prince of Canino, had, indeed, in 1856, proposed to relegate to the branch the vermiform *Sagitta* as the representative of a peculiar class exhibiting a retrograde metamorphosis; but the suggestion fell still-born, and no further attention has been paid to it. Lately, however, there has been a disposition to modify the limits of the branch in opposite directions. Semper, for example, wished to eliminate *Branchiostoma* (*Amphioxus*), or the class of Leptocardians, from the group, while others have been disposed to approximate to it the Tunicates, which for

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* By Professor Theodore Gill, of Washington, D. C.

a long period were regarded as Mollusks. These diverse tendencies have been both exemplified during the past year.

On the one hand, like Semper, Mr. Hoppe-Seyler urges the separation of *Branchiostoma* from the Vertebrates, and expresses surprise that systematic zoologists should have so readily associated the type with the members of that branch; he contends that the Cephalopods are even nearer the Vertebrates than is *Branchiostoma*, and affirms that the form in question has nothing in common with the Vertebrates but the *chorda dorsalis* and the development of the venous system above it and the alimentary canal below: "It differs," he says, "from the Vertebrates in having no brain, no closed vascular system with red blood-corpuscles, no bile-secreting liver, and no gelatin-yielding tissue." In consideration of these deviations and the facts in the development and composition of the tissues of animals generally, he arrives at the conclusions noted adverse to the association of *Branchiostoma* with the Vertebrates. On the other hand, Professor E. Ray Lankester, of Oxford, in "Notes on the Embryology and Classification of the Animal Kingdom," published in the *Quarterly Journal of Microscopical Science* for October, 1877 (vol. xvii., p. 399–454), has claimed not only *Branchiostoma*, but also the Tunicates, to be representatives of the Vertebrate branch—or "phylum," as he prefers to call it; and forms for the Tunicates, under this phylum, a "branch" named *Urochorda*, co-ordinate with two other branches—*Cephalochorda*, represented by *Amphioxus*, and *Craniata*, constituted by all the remaining Vertebrates. He thinks, like Dr. Anton Dohrn, that evolution may tend in different directions, and that, although on the whole it is in the direction of progression from the low to the high, it may be, and in a number of cases he believes actually has been, towards degradation. "So strong," says he, "is the case in favor of degeneration, that at present all that can be said against it and in favor of progression, with regard to any particular case, is this—that the general doctrine of evolution justifies us in assuming, at some period or other, a progression from the simplest to the most complicated grades of structure; that we are warranted in assuming at least one progressive series leading from the monoplast to man; and that *until we have special reason* to take a different view of any particular

case, we are bound to make the smallest amount of assumption by assigning to the various groups of organisms the places which they will fit into, on the supposition that they do represent in reality the original progressive series. . . . When, therefore, the hypothesis of degeneration presents itself as a solution of any special morphological difficulty, we need have no scruples or prejudices in favor of the doctrine of universal progression which should prevent us from accepting it." Thus reasoning, he urges that the Tunicates are degraded Vertebrates; that their systematic relations with the members of that group are evidenced by the chorda of the larval stage; and that there has been quite a general tendency towards degeneration in these animals.

Professor Lankester has further expressed his views of the classification of the Vertebrates, as well as other types of the animal kingdom, in the following condensed arrangement:

BRANCH A.—UROCHORDA.

(1.) I. Larvalia ("Tunicates" of genera *Appendicularia* and *Kowalewskyia*).
(2.) II. Saccata ("Tunicates" of typical form).

BRANCH B.—CEPHALOCHORDA [=Leptocardia, Haeckel].

(3.) I. Leptocardia [=Acrania, Haeckel].

BRANCH C.—CRANIATA [=Pachycardia, Haeckel].

Grade A.—Cyclostoma (Monorrhina [Haeckel]).

(4.) I. Hyperotreta.
(5.) II. Hyperoartia.

Grade B.—Gnathostoma (Amphirrhina [Haeckel]).

Sub-grade A.—Heterodactyla branchiata [= Lyrifera, Gill].

(6.) I. Pisces (with sub-classes Selachii, Holocephali, Ganoidæ, Teleostei).
(7.) II. Dipnoi.

Sub-grade B.—Pentadactyla branchiata [= Batrachopsida, Gill].

(8.) I. Amphibia (with sub-classes Lissamphibia [=Uro-

dela and Anura] and Phractamphibia [=Labyrinthodonta+Gymnophiona]).

Sub-grade C.—Pentadactyla lipobranchia.

BRANCH A.—MONOCONDYLÆA [=Sauropsida, Gill].

(9.) I. Reptilia (with sub-classes Chelonia, Lepidosauria, Pterosauria, Dicynodonta, Ornithoscelida, and Crocodilia.

(10.) II. Aves.

BRANCH B.—AMPHICONDYLA [=Malleifera, Gill].

(11.) I. Mammalia (with three grades, viz., Cloacalia [=Monotremata], Marsupialia, and Placentalia, and with six sub-classes under Placentalia—viz., Edentata, Ungulata, Proboscidea, Chelophora [=Hyracoidea], Carnaria [=Carnivora +Pinnipedia+Cetacea] and Discoplacentalia).

A few remarks as to the issues involved may be in place here.

It is safe now to affirm very positively that *Branchiostoma* has been generally, until lately at least, associated altogether too closely with the craniate Vertebrates, and that there can be no doubt but what the hiatus between it and the typical Vertebrates is greater than is that between any other classes of the branch. The facts remain, however, that morphologically *Branchiostoma* is by far more readily comparable with the Marsipobranchiate Vertebrates than with any other type, and that as to most of its peculiarities of organization, it is not now difficult to appreciate the homologies with the several systems in the latter: the denial of the title of *Branchiostoma* to rank among the Vertebrates because certain physiological functions are not carried on as in the higher Vertebrates is a denial of the now generally recognized dogma that physiology must not be allowed to interfere with morphology in our appreciation of the relations of living beings. We must admit that *Branchiostoma* is not only not a fish, but quite remote from the true fishes; but it certainly seems to be more nearly related to the Vertebrates than other animals, and, in fact, to be a

Vertebrate, however low its structure may be. But, we repeat, the divergence of *Branchiostoma* from the other Vertebrates is very great; and there can be little, if any, doubt that if we desire to express the degree of relationship of animals by taxonomic devices and in our nomenclatures, and accept the word "class" for groups like the Birds, on the one hand, and the Reptiles, on the other, we must assuredly entitle *Branchiostoma* with class rank, and, proceeding in the same direction, even contrast it with all the other Vertebrates.

As to the combination of the Tunicates with the Vertebrates, there may be room for more difference of opinion; but whatever may be the ultimate verdict, it will probably be regarded by the great majority of naturalists as premature. The classification proposed by Professor Lankester is rather different in other respects from that generally adopted. Professor Lankester has for the first time differentiated as classes the *Hyperotreta* (Myxines) and *Hyperoartia* (Lampreys), which have been usually regarded as simple orders of one class—the Marsipobranchiates. The differences between the *Hyperotreta* and *Hyperoartia*, as well as those between the *Pisces*, as represented by the Polypterids, and the *Dipnoi* are generally regarded, in fact, as of less systematic value than those between the true Fishes and the Selachians. The groups of placental mammals called "subclasses" have also for the first time been entitled such by Professor Lankester. Earlier names of some of the other groups are indicated within brackets.

Origin and Relations of the Vertebrates.

The questionable character of the union of the Tunicates with the Vertebrates in a group differentiated from and coordinate with other primary divisions of the animal kingdom has been indicated. A distinguished German naturalist, Professor Carl Semper, in the past year, has even contended that the relations of the Vertebrates are most intimate with the Articulates, and revives, but with some essential modifications, the old view of Geoffroy St.-Hilaire, that the Articulates are homologous with Vertebrates, reversed and progressing with back downwards. Semper maintains that the Arthropod Articulates and Vertebrates are descendants from

a common stock, of a type to which the existing Annelids are the nearest relations; that the central chain and œsophageal ganglion of the Arthropods and worms correspond to the spinal chord and brain of the Vertebrates; and that the nerves proceeding from the ganglionic chain represent the spinal nerves. The presence in worms of a notochord, the mode of development of the heart, the situation of the principal vessels, the course of the blood, and the position of the segmental organs in those animals—all testify to the relationship of the animals under consideration; but of more significance than all is the development: the evolution is doubly symmetrical in the Annelids, and thus agrees with that which has been observed in the Articulates and higher animals, and in the last are traces of that opposition of the cephalic and anal regions which is so characteristic of the Annelids. In fine, Professor Semper believes that the Annelids, Arthropods, and Vertebrates belong to one great group, of which the Annelids are the most generalized and the Vertebrates the most aberrant type.

Fishes of the United States.

The additions to the fish fauna of the United States have been numerous, and several of them especially noteworthy. The species of the fresh as well as salt waters have also been so far studied as to enable us to form an approximate idea of the wealth of our fauna. The species of the eastern coast are not far from 500 in number; those from the western, so far as known, amount to nearly 400. Of the fresh-water species over 600 appear to be tolerably well discriminated.

The most interesting species added to the east-coast fauna have been obtained from certain banks, or in moderately deep water at some distance from the shore-line. Among them are several species previously only known from the high north: such are the *Stichœus punctatus*, *Eumicrotremus spinosus*, *Icelus uncinatus*, and *Triglops Pingelii*, most of which had been found in Greenland or equally northern waters, but all of which were discovered during the past summer off the coast of the United States at depths of from sixteen to ninety fathoms; others were new to science. They have been described by Professor Goode and Dr. Bean under the names *Macrurus Bairdii* and *Lycodes Verrillii*, and one by

Dr. Gill as *Chimæra plumbea*. The *Macruri* and *Lycodes* were previously not known to be denizens of waters near our coasts, and the *Chimæra* is especially interesting as being the representative of a sub-class not believed until now to have members in the Western Atlantic north of the West Indies. The *Chimæra* reaches quite a large size (four or five feet), and has several peculiar characters. It is well to remind our readers that the deep water in which these species have been found approximates in temperature to that of the more superficial northern seas.

Several groups of special interest to the American student have been reviewed and their classification revised by Professor Jordan.

The Northernmost Fish.

The northernmost fish known was found by Captain Feilden during the Arctic Expedition of 1875–76, and is a Salmonid of the same genus as the British chars and the common brook trout of the Eastern United States—that is, a species of the genus *Salvelinus*. It has been called by Dr. Günther *Salmo arcturus*. Several specimens, twelve inches in length or less, were obtained from Victoria Lake, in lat. 82° 34′, and from fresh-water fiords of Floé-berg Beach, in lat. 82° 28′.

Ceratodontids.

Our readers have doubtless some ideas respecting the characteristics of the living Ceratodontids of Australia, so interesting on account of their relations to the forms that became extinct in the northern hemisphere after the Triassic epoch. The habits of some living individuals preserved in a tank have been the subject of observation by Mr. E. Pierson Ramsay: "Their chief mode of progression is by waves of the tail, or by paddling with the pectoral fins alone (without either moving their posterior pair of fins or the tail). When at rest on the bottom of the tank, the pectorals are placed at nearly right angles to the body, the posterior fins lying parallel to the tail. If not disturbed, they will remain in this position for hours, and only when stirred up think it necessary to use their fins and tail at all. They then lash out with their great strong tail, and, turning sideways, squeeze in between some tufts of grass. They are exceedingly eel-like in their motions; and when going slowly along, the

swaying of the great caudal fin gives them a serpentine course." It is doubtful whether they ever go quite out of the water to graze, as has been so often reported; for they are too bulky to progress by their fins, and not sufficiently elongated to go snake or eel fashion, and they also evince dislike to being kept out of water for any length of time.

The Catfishes.

The species of catfishes occurring in our fresh waters have received the attention of Professor Jordan, and to him are we indebted for a thorough and much-needed revision. Professor Jordan adopts the group, as well as the genera, established by Gill, and recognizes thirty species within the United States. These species belong to four genera, which are, on the whole, very well marked. (1) The common catfishes—the stout-bodied and rounded or square-tailed species—belong to the genus *Amiurus:* of these there are seventeen species; (2) the channel cats—slender, forked-tail species—are three in number, the most common and widely diffused being *Ichthælurus furcatus;* (3) the mud-catfish of the Ohio valley—a very long, depressed, and mud-colored fish—represents alone the genus *Pelodichthys;* finally, (4) the stone-cats—distinguished by an eel-like tail and flat head marked by a crucial depression behind—represent the genus *Noturus*, of which there are eight species. The common error that the largest species of the family is a channel cat has been corrected by Professor Jordan, and it is shown that the great catfish of the Mississippi valley is not an *Ichthælurus*, but an *Amiurus*, and the same as the *Amiurus nigricans* of the Great Lakes.

Suckers.

The so-called "Suckers" of the American fresh waters constitute a family rich in species in the United States, but elsewhere only found (under two generic types) in Northeastern Asia. Twelve distinct genera are now known, and not the least interesting of them is one lately discovered by Professors Jordan and Braxton during a tour made through the Southern States in the interests especially of ichthyology. The newly acquired form has the usual Catastomid physiognomy, but is distinguished by a very peculiar lower jaw and lip. The jaw is deeply split in the middle, and thus has the

appearance of two lobes, one on each side, and, instead of being invested with a thick fleshy lip, has a sheath-like pellicle. The upper lip is greatly developed, but not protractile forwards. The form and most other characters are similar to those of *Ptychostomus* or *Myxostoma.* The species occurs in the Tennessee and Cumberland rivers, and is apparently not uncommon, being known to the inhabitants of the borders as the "Hare-lip" or "Split-mouth Sucker." The technical designation *Lagochila lacera* has been conferred on it by Messrs. Jordan and Braxton.

The Sunfishes and Black Bass.

One of the most characteristic groups of American fishes, and one almost entirely confined within the limits of North America this side of the tropic of Cancer, is the family of Centrarchids, which includes the sunfish, rock bass, black bass, and a large number of related forms. The species of this family have been systematically re-examined by Professor Jordan, and fifty-six species are recognized as having tolerable claims to rank as valid species. These species are distributed among sixteen genera, grouped under three subfamilies—viz., (1) the *Micropterinæ*, with the single genus, *Micropterus;* (2) the *Lepiopominæ*, with thirteen genera; and (3) the *Centrarchinæ*, with two genera, *Centrarchus* and *Pomoxys.* The genera richest in species are *Lepiopomus* and *Xenotis*, each of which has thirteen species. To these two genera and to *Eupomotis* belong most of the common sunfishes of our Eastern waters, as well as those of the Mississippi valley. The family is, however, poorly represented in the streams of the Atlantic seaboard, and the most characteristic is the common sunfish—*Eupomotis aureus.* To the genus *Micropterus* belong the black bass (*Micropterus salmoides*) and the widely diffused Oswego bass (*Micropterus pallidus*).

The Etheostomids.

Another equally characteristic group, but less conspicuous in its species on account of their small size, is the family of Etheostomids. The species of this family have likewise been re-arranged by Professor Jordan, and its fifty-eight determinable species referred to eighteen genera. The species are

generally diffused, but they are most abundant in the streams of the Mississippi valley and the Southern States. They are small, perch-like fishes, and may even perhaps belong to that family. A singular variation is exemplified in the development of scales and of the lateral lines; while most of the species have the body more or less completely covered with scales like those of the perches, a few are nearly scaleless. In *Amocrypta*, for example, the body is almost entirely naked, the scales being confined to the caudal peduncle and lateral line.

A New North American Family.

In a collection of fishes sent to Professor Jordan by Professor H. S. Reynolds from the Little Red River, White County, Ark., were found two specimens of the little fish which Professor Jordan has considered as the representative of not only a new genus, but a new family, or at first a subfamily, of *Centrarchidæ*, whose nearest relations are to be found in some extinct forms recently described by Professor Cope. In form and external aspect it is said to have some resemblance to *Aphredoderus*, but is more compressed. The dorsal fin has five spines, the anal three; the ventrals are thoracic and normal in situation; the branchiostegals are five, and the membrane is broadly united across the pectoral region; the lateral line is absent; the pharyngeal apparatus is unknown. It is suggested by Professor Jordan that the type is most nearly related to the *Centrarchidæ*, or perhaps the *Cichlidæ*. Its position must, however, of course be provisional, and it remains to be determined from the examination of good specimens what are the true relations. The single species has been named *Elassoma zonata*.

Gigantic Tortoises.

An interesting and noteworthy peculiarity in geographical zoology is the distribution of the gigantic species of land tortoises of the genus *Testudo*. These are now entirely confined to three archipelagoes—(1) the Galapagos Islands westward of the coast of South America; (2) the Mascarene islands Mauritius and Rodriguez; and (3) the Aldabra group, small islands lying northwest of Madagascar, in lat. 9° 25′ S., long. 46° 20′ E. It has long been known that these several archipelagoes were the abodes of large land tortoises,

but the numbers and distinctions of the species were involved in considerable doubt. With a view to settle the doubtful questions, Dr. Günther, of the British Museum, availed himself of the chance afforded him by considerable collections amassed from time to time in London, and chiefly at the British Museum, and has investigated the species and their distinctions. In a recently published richly illustrated volume he has given the results of his final examinations. Not less than fifteen species have been recognized either in a living condition or recently exterminated; these can be segregated into several groups coincident with their geographical range and distinguished by characters derived from the shell, so that hitherto indeterminable shells in museums may be at least referred almost certainly to the archipelago from which they may have been derived, even if no other information can be obtained. The tortoises of the Aldabra Islands have a small anterior unpaired "nuchal" plate in the upper shell, or carapace, and a pair of anterior gular plates in the lower or plastron; those of the Mascarenes have no nuchal, and the gular is single; and those of the Galapagos are also destitute of the nuchal plate, but have a pair of gular ones. So localized are the species that each island almost has its own peculiar form. On the Aldabra Islands still survive at least three, if not four species, and from the Galapagos Islands five living and one extinct species have been obtained; but all of the Mascarene species (five are known from their remains) have become extinct, and since their discovery by the Europeans. The several groups of islands inhabited by these tortoises, as will be recognized, are quite widely distant, and, in the case of the Galapagos, on the one hand, and the remaining islands, on the other, almost as widely separate as could be. They are all situated in the intertropical zone, but have in common otherwise only the negative characteristic of the absence of large terrestrial mammals and that of human inhabitants until recent times. These are doubtless the conditions which favored their development and increase. Historical evidence shows that species existed on all the islands, and were very abundant in individuals. They were exterminated in the Mascarene Islands after their settlement, and but for the absence of permanent settlements on the others would probably have entirely disappeared from the existing

fauna. These tortoises attained a varying size; some even reached a weight of nearly, if not over, 500 pounds, and had shells over six feet long, but most were much smaller. Living to a very great age and with no redoubtable enemies to contend with, they were found by the early visitors to the islands in question in great numbers. According to Leguat, for example (in 1691), "There are such plenty of land turtles in this isle [Rodriguez] that sometimes you see two or three thousand of them in a flock, so that you may go above a hundred paces on their backs." These numbers, however, were soon diminished; the animals afforded savory and nutritive meat which formed a most agreeable variety for the mariner, and consequently they were taken in quantity and stored on shipboard for future consumption. Only the difficulty of access to the islands prevented their complete annihilation.

The question arises, What is the significance of the occurrence of these animals in such widely remote regions without any representatives in intermediate ones? "The naturalists," says Dr. Günther, "who maintain a common origin for allied species, however distant in their habitats, will have to assume a former continuity of land . . . between the Mascarenes and Africa, between Africa and South America, and, finally, between South America and the Galapagos. A continuity of land in this direction is more probable than one in the opposite hemisphere, which would extend over 210°. Indeed, the terrestrial and fresh-water faunæ of Tropical America and Africa offer so many points of intimate relationship [see, *e. g.*, *Annual Record* for 1876, p. clxvii] as very strongly to support such a theory. The tortoises, then, would be assumed to have been spread across the whole of this large area, without being able long to survive the arrival of man or large carnivorous animals." In the face of any formidable enemies, great size in such animals would be disadvantageous, inasmuch as it would render them conspicuous and prevent them from obtaining shelter, while their defensive ability would not be correspondingly increased; small size would be advantageous in relation to their environments, and hence small species of the same genus have survived and still exist over large continental areas.

Birds.

In ornithology there has been apparently an average degree of activity. Many catalogues of species of different regions and descriptions of a number of new species have been published, but none, so far as we are aware, of sufficient interest to be here particularized. The third volume of Sharpe's "Catalogue of the Birds in the British Museum;" parts of Gould's great illustrated works on "The Birds of Asia" and "The Birds of New Guinea;" Sharpe's edition of "The Birds of South Africa" by E. L. Layard; Hartlaub's "Birds of Madagascar and the Neighboring Islands" ("Die Vögel Madagascars und die benachbarten Inselgruppen"); and the first of "A Monograph of the Bucerotidæ, or Family of the Hornbills," by D. G. Elliot, are among the most noteworthy, either on account of extent or as good monographs.

Avifauna of Madagascar.

For many reasons one of the most interesting faunas of earth is that of Madagascar and the Mascarene Islands. In 1861 Dr. Hartlaub had published a small ornithological contribution to the fauna of Madagascar; and last year he gave the results of his own continued studies, and embodied as well those of his numerous fellow-ornithologists, in a volume of over 400 pages. It seems that there are now known as inhabitants of the region in question 284 species: 220 occur in Madagascar and 104 are peculiar to that island; 44 are to be found in the Comoro Islands, about 60 in each Mauritius and Bourbon, and 25 in Rodriguez. "The individuality of the fauna of Madagascar," says Dr. Hartlaub, "is so unique that even that of New Zealand can hardly be compared with it. Wallace's attempted parallel between Madagascar and Africa and the Antilles and South America is, in our eyes, sufficiently disproved by the occurrence in the Antilles of *Trochilidæ*, one of the most characteristic forms of South America. But in Madagascar not a single one of the genera most characteristic of Africa occurs. The originality of the fauna is much too pronounced to allow Madagascar to be treated of only as a 'sub-region' or an 'aberrant part' of the Ethiopian region." From this conclusion (reproduced in *Nature*) Professor Newton has, however, dissented, and al-

though he does not "wish that its extraordinary peculiarities should be undervalued," he does "not want them to be unduly magnified at the expense of those of the fauna of New Zealand."

The Wild Camel.

Little is known of the camel in a truly untamed condition —that is, not in simply a feral state; but during the past year observations have been recorded respecting the wild animals occurring in Central Asia. The camel is still found in an aboriginal condition in the Desert of Gobi. It is two-humped, and, according to Mr. Harkloff, "the size is nearly that of the tame; but it is larger and higher on the legs. It is of a darker color than the tame; and the white around the nose is much clearer and paler. In the spring they pair, and the time of gestation is the same as that with the tame camel. The Tanguts and Kirgizes hunt the wild camel and eat its flesh; also they use the hair. The wild camel is said not to be shy, and accordingly not difficult to obtain." According to Major Tichannoff, it cannot easily, if at all, be tamed. The voice is not so strong as that of the tamed camel.

Deer's Antlers.

The morphology of the antlers of the deer has been investigated by Messrs. A. H. Garrod and Theodore Gill. Professor Garrod has suggested that the typical antler is composed of a primarily bifurcate beam and a brow antler springing from its base anteriorly, and that the differences between the species result from the greater or less development, or the atrophy, of one or other of these elements. Several cases, however, are not explicable by this hypothesis. Professor Gill considers the antlers "either as simple spikes or with a tendency to bifurcation, especially (but not exclusively) in the direction of the varying greatest or axial growth," and has applied a new terminology to indicate at once the order of development and as a convenient device for descriptive zoology. (1) The simple spikes of the first year and their after-growths are designated *protoceres;* (2) the anterior offshoots of the second year *deuteroceres;* and the succeeding (3) third, (4) fourth, and (5) fifth anterior offshoots, respectively, (3) *tritoceres*, (4) *tetartoceres*, and (5) *pemptoceres*. The chief differences in the several genera of deer with com-

plex horns result from the direction of the main axis or line of greatest increase: in the wapiti, or American elk, as well as in the stag of Europe, this is along the *protoceres* throughout, while in the common Virginian and long-tailed deer it is procurrent subspirally into the *tritoceres*. The Elaphure of China is anomalous in the excessive development of the *deuteroceres*, or homologues of the brow-antlers of the wapiti and stag, and the inverse reduction of the other elements.

The Placenta of Prosimians.

One of the most interesting groups of mammals is that of the Prosimians, comprising the lemurs, the *Tarsius*, and the aye-aye, most of which are found in the great island of Madagascar. The special interest arises from the fact that, in many points of structure, they approach the apes and man more than does any other form. On account of the possession of their many common characters, the two groups of Apes and Prosimians have been, by most writers, combined under the ordinal designation of *Primates*, although quite a number of prominent naturalists have urged that the two should be differentiated as distinct orders. The question was reopened several years ago by Mr. A. Milne-Edwards, who examined the placentation of several species of Prosimians, and found that it differed widely from that of the Apes. The placentation of species of the group has still more thoroughly been investigated, during the past year, by Professor W. Turner, of Edinburgh, who has in part confirmed and amplified the observations of Mr. Milne-Edwards. His examination extended to three species—viz., *Lemur rufipes*, *Propithecus diadema*, and *Indris brevicaudata*.

A number of prominent zoologists have combined the orders of placental mammals under groups distinguished by the placenta. In one type, as in Man, the uterus develops a decidua, and the placenta is discoidal; such are Man and the Apes, the Bats, the Insectivores, and the Rodents. In others the placenta is deciduate and zonary, as in the Carnivores and the Proboscideans; and in a third the uterus develops no decidua whatever, as in the Ungulates and Cetaceans. Until the discovery of the placentation of the Lemuroids, it had been very naturally assumed that they possessed a discoidal deciduous placenta like the apes. It is

now satisfactorily proved, however, that no decidua is developed, and the placenta exhibits a modification of a zonary form. "Both in form and structure," says Mr. Turner, "the placenta in the lemurs is without doubt a diffused placenta."

The question naturally arises, What is the value of the placental characteristics of the Prosimians? Are those animals related most to the other forms developing a decidua, or to the Primates, with which they have been hitherto generally associated, or at least approximated to? Professor Turner has quite judiciously treated this question; and has contended that in spite of the placental characters, the Prosimians are closely related to the typical or ape-like Primates, with which they agree, or most resemble in a number of osteological and cerebral characters. He urges, however, that the two groups are entitled to ordinal value; the apes, with man, belonging to one (Primates), and the lemurs and related types to the other (Prosimians). He urges, with considerable force, that the non-deciduate "diffused placenta has the most simple mode of structure, and that the distribution of the villi over the surface of the chorion presents a closer approximation to the primary embryonic arrangement; while the discoid placenta exhibits the greatest departure from the diffused villous chorion of the early embryo." It is therefore probable, he thinks, that the mammals with discoid deciduate placenta have diverged from those characterized by a non-deciduate one. He has shown, too, that the line of demarcation between the non-deciduate and deciduate placentiferous mammals is not so abrupt as has usually been supposed, but is graded over by an intermediate arrangement—"the passage from the diffused placenta, in which no maternal tissue deciduates during parturition, to those deciduate placentæ in which both the epithelial and subepithelial vascular tissue of the uterine mucosa are shed being effected through the cotyledonary placenta, in which the epithelial lining of the maternal cotyledons separates along with the fœtal villi." There is, besides, considerable variation in the relative proportions of the tissues.

INVERTEBRATES.

Protozoans, Sponges, and Worms.

"Studies among Amœbæ" is the subject of an article in the *Popular Science Review* for July, by Professor P. M. Duncan, who describes the habits and figures of some of the forms of these protozoans. Of the twenty or more species described by German and English observers, Duncan believes that there are but two truly specific forms, *Amœba villosa* and *Amœba princeps.*

Dr. Leidy has observed a species of infusorian, probably *Chilomonas*, existing in immense numbers on the sandy beach of Cape May, where they formed a thin yellowish-green film, coloring the surface of the sand.

An important work on the development of the egg has been published by O. Bütschli, who is well known by his studies on the Infusoria and the lower worms, especially the Rotifera and the Nematode worms. As regards the process of conjugation among the Infusoria, Bütschli, according to a review of his work in *Nature*, thinks that it is merely a *rejuvenescence* of the creatures which undergo it, enabling them to become "the stem ancestors of a series of generations which propagate by fission." This is contrary to the view of Balbiani, Stein, and others, who maintain that the act of conjugation so well known among the *Paramecia*, *Vorticellæ*, etc., is the precursor of a sexual mode of generation. The reviewers, Messrs. Dallinger and Drysdale, disbelieve in Bütschli's theory, and suggest that "what he calls rejuvenescence is one of the many modes by which rapidity of fissiparous multiplication is in some organisms aided, and the necessity for the true act of fertilization is made less frequent."

The foraminiferous forms — shall we say *varieties* or *species?*—of Barbadoes have been studied by Van den Broeck. His material was received from the West Indies, having been collected by the late Professor Agassiz. He concludes, with all others who have studied these exceedingly variable forms, "that the terms genus, species, variety, have a very different and broader acceptation than we usually suppose."

A severe *critique* on Dr. W. B. Carpenter's views regarding certain groups of *Foraminifera*, by Dr. G. C. Wallich,

appears in the *Annals and Magazine of Natural History* for February.

The fresh-water Rhizopods, a favorite subject of inquiry, have been studied with great care by Hertwig, Lesser, and Bütschli. An abstract of their works has been given by Mr. Archer in the *Quarterly Journal of Microscopical Science*, the third part appearing in the January number.

Barrois finds that the sponges of the different groups studied by him present the same essential processes of development, but that these stages appear in a different order, and more or less modified by different circumstances, in the different groups. This general mode of development, or primitive cycle, does not seem to him to be a *gastrula* fixed like a hydra, and of which the inner layer is ramified into a gastro-vascular system, as Haeckel supposes, but a compact mass composed of two layers, the exterior representing the exoderm, the interior the union of an internal and middle leaf. From the middle layer arise the spicules. The oval gastrula becomes fixed by its posterior end, and then becomes flattened and irregular in form; cavities then appear in the endoderm, or innermost layer, which are lined with the peculiar ciliated cells found in sponges; and the oscules then appear, by which water enters and bathes the cavities within. These observations of M. Barrois do not seem to sustain Haeckel's views as to the relationship of the sponges to the polypes, with which he unites them.

While Mr. Carter continues, in the *Annals and Magazine of Natural History*, his papers on sponges, a memoir by Professor Haeckel forms the second number of his "Studies on the Gastræa Theory." It contains, however, besides considerable theoretical matter, many new facts regarding certain simple sponges called *Haliphysema* and *Gastrophysema*. They are so simple in organization as to bear considerable resemblance to the gastrula form of sponges, which, it may be remembered, consists of a two-layered hollow sac. It is illustrated by six well-drawn plates.

The commercial sponges of our southern coast have been described and figured by Professor Hyatt in a lengthy memoir published by the Boston Society of Natural History, in which he describes the mode of fishing for them, as well as the manner in which they are prepared for the market.

Hyatt also discusses the influence of the nature of the sea-bottom and the temperature of the water on variations of forms and their distribution. He claims that these animals are directly modified by changes in the physical surroundings, and he cannot imagine the intervention of natural selection, since "the uniform action of a given temperature, depth, amount of sediment, sheltered locality, etc., have a corresponding uniformity in results, and are sufficient in themselves to account for the general modifications described."

A number of new Caribbean sponges are described in the *Annals and Magazine of Natural History* by Thomas Higgin.

Certain minute parasitic worm-like organisms, called *Dicyema* and *Dicyemella*, which live in the liquid bathing the spongy bodies (perhaps renal organs) of cuttle-fishes, have been studied in all their phases of development by a Belgian naturalist, E. Van Beneden, who concludes that they form the type of a new sub-kingdom of animals, which he calls *Mesozoa*.

It appears that tape-worms may occur abundantly in the intestines of rabbits, as stated by Mr. G. J. Romanes in *Nature*. This is an unexpected fact, since the rabbit is purely an herbivorous animal. The fact is explained by Mr. R. D. Turner in a letter to *Nature* (February 15), who says: "I would suggest that the tape-worm referred to by Mr. G. J. Romanes is like the *Bothriocephalus* of man, perhaps a species of the same genus. This is not supposed to have a cystic state, but to be developed from a ciliated embryo taken into the system in raw or badly cooked vegetables which have been watered by sewage from cesspools, in which the eggs will remain alive for months. In the same way the eggs of the rabbit's tape-worm probably remain in the animal's droppings till set free in rain as ciliated embryos. As the rabbit feeds on the vegetation watered by such rain, there is no difficulty in understanding how the embryos would reach his alimentary canal."

Some of the fluke-worms (*Distoma*, etc.) of Scandinavia are described and figured by Olsson in the *Transactions* of the Swedish Academy.

The classification of the lower worms, especially the flat worms, forms the subject of two elaborate papers by Mr.

C. S. Minot. He finds that these worms (*Turbellaria*) are much more highly organized than is usually supposed. It has been frequently stated that some or all parts of these worms are formed by a protoplasmic substance, and not of cells, and a relationship with the Infusoria has therefore been supposed to exist. Minot finds, however, that all the tissues in the forms he studied are composed of cells, as had been stated previously by several observers. Minot finds that the parenchym, which about a year ago was not supposed to be cellular, is, in the twenty different species he studied, "mainly composed of ramified stellate cells, whose processes intertwine and unite adjacent cells." These worms are hermaphroditic, and Minot describes the egg-food stock or yolk-gland which he has discovered in the flat worms. This gland "produces cells, which remain alive, and pass down a separate duct that ultimately joins the oviduct. The cells are then thrown together with an egg-cell, and the whole cluster of cells is covered over by a shell. . . . The egg as laid consists of the egg proper and the food-cells which are used up to nourish the egg as it grows. This curious economy is unknown outside of the Plathelminths." Minot unites the Trematode (flukes) and Cestode worms (tape-worms) into one group, under the name of *Vaginiferæ.* In its more extended form the paper is published, with five excellent plates, in Semper's "Arbeiten aus dem Zoologisch-Zootomischen Institut in Würzburg," an abstract appearing in the *Proceedings* of the Boston Society of Natural History.

The anatomy of a singular worm (*Phascolion strombi*) is figured and described by Théel in the Swedish *Transactions.*

Mr. H. N. Moseley, naturalist on board the *Challenger* during her three years' cruise, has given an account of two new and remarkable species of deep-sea Ascidians. One of them, *Hybythius calycodes*, was brought up from the North Pacific from a depth of 2900 fathoms. It is stalked and cup-shaped, and is believed to be allied to *Boltenia.* It differs from that genus, however, in possessing a series of cartilaginous plates symmetrically developed in the soft test. The second species, *Octanemus bythius*, was brought up from a depth of 1070 fathoms. It is star-shaped, with eight rays. The gill sac is

nearly absent in it, and the usual gill net-work entirely so. Muscular prolongations of the tunic run into the curious conical protuberances of the test. The nucleus is contracted and small, like that of *Salpa.* This singular species is believed to be without living allies.

Professor Semper has published an interesting volume upon the supposed homologies in the structure of articulated animals and vertebrates.

Echinoderms.

Among recent contributions to the developmental history of animals is a paper on the development of a sea-cucumber (*Cucumaria doliolum*). After fecundation the nucleus diminishes, and becomes a mere drop of protoplasm, inside which a germinal speck appears in an hour or two. The segmentation of the yolk goes on until two hundred and fifty cylindrical flagellate cells are formed. After the formation of the single-layered blastoderm, the embryo breaks through the egg-skin, and swims freely by means of its ciliated membrane. As the flagella gradually disappear, its activity is reduced to a backward and forward motion; and when the tentacles are protruded, it sinks to the ground, and moves only by crawling.

Important papers on the anatomy of the sea stars and urchins have been published by R. Teuscher in the Jena *Zeitschrift*, illustrated by excellent plates. The last number contains a useful *résumé* of his researches on the circulatory, water, and nervous systems, and on the integument. Dr. Carpenter has studied the structure of the *Comatula* star-fish, with a note on the nervous system and muscles of the sea-urchins.

Professor Loven, of Stockholm, has published in the *Transactions* of the Swedish Academy an elaborate work, in quarto, on the Sea-urchins (Echinoids), which is illustrated by an atlas of fifty-three plates. The work is mostly taken up with an account of the hard parts forming the shell of the *Echinus*, but also contains an account of certain bodies called *sphæridia*, and an elaborate drawing and explanation of the nervous and water-vascular systems of *Brissopsis lyrifera*, greatly advancing our knowledge of the anatomy of these animals.

Mollusks.

In a recent lecture on the forms of passage between the Annelids and Mollusks, Professor Perrier seems to adopt the idea, already suggested by two or three naturalists, that the Mollusks are in reality, to use Perrier's own words, "worms condensed into two or three segments." Is this the beginning of the end, and are we finally to regard the Mollusks as originally descended from worm-like forms, and therefore as not forming a distinct sub-kingdom of animals?

The anatomy of the common mussel (*Mytilus edulis*) is elaborately treated by A. Sabatier in the *Annales des Sciences Naturelles.* The essay fills 132 pages, and is illustrated by nine folding plates.

In an essay on the Pliocene fresh-water shells of Southern Austria, by Dr. Neumayr and Herr Paul, the authors describe numerous modifications of the genus *Vivipara*, or *Paludina*, which occur in prodigious abundance throughout the whole series of fresh-water strata. Of this genus there are forty distinct *forms* (Dr. Neumayr very properly hesitates to call them all *species*), which are named and described in this monograph, and between which, as the authors show, many connecting links, clearly illustrating the mode of derivation of the newer from the older types, have been detected. The authors, remarks Mr. J. W. Judd, in *Nature*, have demonstrated that the species with highly complicated ornamentation were variously derived by descent—the lines of which are in most cases perfectly clear and obvious—from the simple and unornamented *Vivipara achatinoides* of the Congerien-Schichten, which underlies the Paludina beds. Some of these forms have been regarded as types of a distinct genus (*Tulotoma*) by Sandberger. "And hence we are led to the conclusion that a vast number of forms certainly exhibiting specific distinctions, and, according to some naturalists, differences even entitled to be regarded as of generic value, have all a common ancestry."

Dr. J. W. Dawson writes to *Nature* that he has found at the South Joggins coal-mines, in Nova Scotia, a number of well-preserved shells of *Pupa vetusta*, the oldest of land shells. It appears that this little shell is found at the bottom and top of beds 2000 feet in thickness, including many

beds of coal, and nearly the whole thickness of the productive coal measures. *Conulus priscus*, the only other land snail found in this section, on the other hand, occurs only, so far as known, in the lowest of the beds above mentioned. Two other Carboniferous shells, *Pupa vermilionensis* and *Dawsonella Meeki* of Bradley, have been found in the coal-beds of Illinois. All these forms belong to generic or subgeneric types still represented in America.

A list of the fresh-water and land shells of Alabama by Dr. James Lewis appears in Dr. E. A. Smith's report on the geology of Alabama for 1876. This state is remarkably rich in Unionidæ and Melanians.

Crustaceans.

We had occasion only a short time ago to notice an elaborate work by Professor Weismann on the theory of descent, and now comes an octavo of nearly two hundred pages on the natural history of the *Daphnia* and its allies, the "water-fleas," so common in fresh-water pools. One chapter is on the formation of the egg in the Daphnoids, another on the dependence of the embryonal development on the germinal fluid of the mother; while the last is on the influence of conception on the production of winter eggs. As a contribution to the physiology of reproduction, the essay is of a high order of merit.

Researches on the mode of respiration in certain crabs, by M. Jobert, and a note on two new species of Crustacea from New Zealand, by A. Milne-Edwards, appear in the *Annales des Sciences Naturelles.*

An eyeless crustacean (*Niphargus puteanus*) inhabiting the Swiss lakes has been minutely described by M. Humbert, who believes it to be an ancient genus, descending from a form which is now extinct, thus corresponding with *Proteus*, *Anophthalmus*, and other cave animals. He says, if we suppose that the genus *Niphargus* appeared before the ice period, it is impossible to say anything with regard to its place of origin; but he believes that it has really originated from forms inhabiting subterranean waters, and which became acclimatized at depths where they found the darkness sufficiently intense. The lake species, he thinks, are living under greater disadvantages than the cave species, and are suffering, as it were, from atrophy.

In a late memoir on the fauna of water deprived of light, M. Ph. de Rougemont, in his studies on the crustaceans *Gammarus puteanus* and *Asellus Sieboldii*, also the snail *Hydrobius*, brings out the fact of the excessive development of the organs of smell in these animals, in which the eye is either absent or very rudimentary.

The external anatomy of a shelled phyllopod (*Estheria californica* Pack.) forms the subject of an essay by Dr. H. Lenz. A number of new North American phyllopod crustaceans are described by Packard in Hayden's *Bulletin* of the United States Geological Survey (Vol. III., No. 1). It appears that the genus *Lepidurus* is better represented in Western and Arctic North America than in any other part of the world so far as known, there being two Western American and one Arctic American species. No species of *Apus* or *Lepidurus* occurs east of the Mississippi valley, and all these phyllopods occur mostly in the Western States. Several new entomostracous crustaceans from Colorado are described by Mr. V. T. Chambers in the same *Bulletin*.

The crustacean fauna of Lake Titicaca itself is very meagre. Except a species of *Cypris*, all the specimens collected belong to one amphipodous genus, *Allorchestes*, which had hitherto afforded but one or two authentic fresh-water species, ranging from Maine to Oregon and the Strait of Magellan. Seven new species are described in this paper from Lake Titicaca. Several are remarkable for their abnormally developed epimeral and tergal spines. Some are also noteworthy as comparatively deep-water forms of a family commonly regarded as pre-eminently littoral. Some of the species occurred as far down as 68 fathoms, the greatest depth of the lake being 154 fathoms. The marine species usually inhabit the shore above low-water mark, and the previously described fresh-water species are found in the shallow water of brooks, pools, or edges of lakes. No strictly fresh-water *Orchestidæ*, the family to which these Crustacea belong, have been reported from the Eastern continent, although a few terrestrial forms are described, says Mr. Faxon, as inhabiting moist soil away from the sea.

The fresh-water Crustacea of Illinois have been enumerated and new forms described by Mr. S. A. Forbes in the *Bulletin* of the Illinois Museum of Natural History, No. 1. A num-

ber of new crayfish are described, and it would seem as if there were no limit to the number of species of this genus. The same journal contains a list of the grasshoppers of Illinois by Professor Cyrus Thomas, and a partial catalogue of the fishes of Illinois by E. W. Nelson.

Insects.

A notable paper, entitled "History of *Phyciodes Tharos*, a Polymorphic Butterfly," by W. H. Edwards, appears in the *Canadian Entomologist.* He finds that there are four generations of this butterfly at Coalburg, W. Va., the first of which is *marcia* and the second and third *tharos*, and none of the larvæ from these have so far been found to hibernate; and the fourth, under exceptional circumstances, has produced some *tharos* and more *marcia* the same season, a large proportion of the larvæ also hibernating. In the Catskill Mountains there are two generations annually, the first of which is *marcia*, or the winter form, and the other is the summer form. Mr. Edwards adds that, in a high latitude or at a high altitude, we might expect to find this butterfly with a single brood, and restricted probably to the winter form, *marcia.* And this is precisely what does occur in the island of Anticosti (about latitude 50°) and on the southern coast of Labrador opposite, *tharos* being the more northern form. All these varieties are produced, according to Mr. Edwards, by changes in climate or temperature. We would add that in this and similar cases studied by Weismann, we see species produced by causes easily understood and measured by the ordinary naturalist, and that phase of evolution called "natural selection" does not enter into the matter at all as a *vera causa;* and we doubt not that Darwinism, as such, has been much overestimated as a factor in producing species—a dogma being mistaken for a genuine cause.

The annual report of Hayden's United States Geological and Geographical Survey of the Territories for 1875 contains a report of over two hundred pages, by A. S. Packard, Jr., on the Rocky Mountain locust and other insects either now or likely soon to be destructive in the extreme Western States and Territories. The report is fully illustrated, and contains maps showing the distribution of the locust, Hessian

fly, wheat-midge, chinch-bug, army-worm of the North, the cotton army-worm, and the boll-worm.

In the *American Naturalist* for July there is a critical notice of a work in Russian, by Ganin, on the metamorphosis of insects. The review has been prepared by Baron R. von Osten-Sacken.

Some attention has been lately paid to stridulation, or the production of sound, in butterflies. Mr. A. H. Swinton finds that the costal vein of *Ageronia feronia*, a Brazilian butterfly, is bare, smooth, and elevated, which, when the wings are spread, is received into a concavity which is in every way suited to act as a clasp, and is sonorous when the wings are moved, while the whole apparatus represents the bristle and catch that lock the wings of the moths. *Vanessa antiopa* also stridulates. Mr. Swinton describes in the May number of the *Entomologist's Monthly Magazine* the various kinds of apparatus in the moths, situated for the most part on the sides of the thorax, while some are said by Westwood to possess musical organs in the abdomen.

Mr. M'Lachlan, in alluding to the *Lepidoptera* brought home by the Arctic Expedition, says that the larvæ of most of these species must of necessity require more than one season to acquire their full growth, for the short, fitful summer was utterly inadequate for the full development of most of the species; and, furthermore, it was probable that the pupa state might habitually last several years.

Professor Westwood has noticed the habit, exceptional in the family *Stylopidæ*, of living as a parasite on a homopterous insect.

An important paper by Professor Plateau on the phenomena of digestion in the harvestmen (*Phalangium*) brings out the fact that the so-called liver of these animals, as well as of spiders and Crustacea, is nothing else than the organ of secretion of a digestive fluid intended for the emulsionizing of grease and the dissolving of albuminoid substances.

Professor Perez has studied the vitellogene cells of the ovaries of insects which give nourishment to the true egg cells of insects, as in certain Crustacea (*Revue Scientifique*, p. 1001).

A new cave fauna, entirely distinct from that inhabiting Mammoth and other caverns in Kentucky, Indiana, and Vir-

ginia, has been discovered by Dr. Packard on the shores of the Great Salt Lake. The different species of animals (a helix, myriopod, harvestman, and poduran) inhabiting the cave are described in Hayden's *Bulletin.*

Professor C. V. Riley's ninth report on the injurious insects of Missouri contains new and fresh information regarding the Western locust, the Colorado potato beetle, with maps illustrating their extension East. Other injurious insects are more or less fully treated.

A work of a very high degree of interest to philosophic naturalists is Professor Weismann's "Studies on the Theory of Descent" ("Studien zur Descendenz-Theorie"), of which the second part has just appeared. It is divided into four sections, with the following subjects: "The Origin of the Markings of Caterpillars;" "On the Phyletic Parallelism in Metamorphic Species;" "On the Transformation of the Mexican Axolotl into an Amblystoma;" "On the Mechanical Conception of Nature." In the last chapter, which will interest thinkers, the author, while stating his belief that evolution has been accomplished mechanically, claims that this view of nature neither leads to materialism nor excludes teleology.

In a recent essay on the origin of insects, Dr. Mayer, of Jena, suggests that the ancestor of the insects was winged. This view is opposed by Dr. Packard, who publishes a review of Mayer's essay in the *American Naturalist* for November, in which he maintains, with other writers on this subject, that they must have originated from larval forms, and claims priority for certain conclusions proposed as novel by Dr. Mayer.

In a recent work on the morphology of the tracheal or respiratory system of insects, Dr. J. A. Palmen arrives at the conclusion that the primitive number of pairs of spiracles, or breathing-holes, in insects is eleven, thus agreeing with the views previously expressed by Packard in a brief essay published on the same subject in 1873. Palmen's work comprises one hundred and fifty pages, and is quite exhaustive. He believes that the tracheal system was at first, in its primitive form, open—*i. e.*, consisting of a series of tubes connecting by spiracles or holes with the outer world. In certain aquatic insects the system became closed, the larva breathing by ex-

ternal gill-like appendages. As to the origin of the tracheæ, Bütschli (1870) believed that their mode of origin was the same as the silk-glands, and that the two sets of organs were homologues, and that they were derived primitively from the segmental organs of worms, which are arranged in pairs along the body of the latter animals. In 1873, Packard suggested that the air-tubes may have originated independently within the body, and afterwards formed a connection with minute pores leading through the skin. In 1874, Semper expressed the same views as those of Bütschli, which in the year after were accepted by Mayer. Moseley regarded them in 1874 as dermal glands modified. Packard then suggested that the tracheal system might be derived from the water vascular system of certain low worms; while, in a late paper on the development of the *Lepidoptera*, Hatschek conceives that the air-tubes are derived from respiratory portions of the skin much enlarged. Finally, Palmen appears to adopt the view that the tracheæ may have originated from the segmental organs of the jointed worms, which in turn originated from the dermal excretory glands of the lower unjointed worms. This shows how conjectural is our knowledge of the origin of these interesting organs. He conceives that the excretory function of the primitive lung-sac was afterwards replaced by an absorbing function, and the sac or tube became a respiratory organ—viz., a trachea, which (at first simple and sac-like, due originally to an in-pushing of the skin) became longer and branched, until it assumed the present form. With this view we should not be disposed to find fault as a provisional hypothesis.

Sir John Lubbock, in a fourth communication to the Linnæan Society (reported in *Nature*) on the habits of bees and wasps, illustrated by ingenious experiments his *modus operandi* of testing their faculties, dispositions, habits, etc., by something of a double F apparatus, whereby an interval of three tenths of an inch, either by a drop from above or reaching upwards the distance from below, alone prevented ants from gaining access to a covered glass all filled with larvæ. They evidently had not the acumen to surmount the three tenths of open space, although they had for hours before been traversing the route and carrying off larvæ previous to the small gap being made. Industry was conspicuously shown

by one specimen, which Sir John used to place in solitary confinement in a bottle for hours, and once for days; but the moment released it commenced its laborious larvæ-gathering propensities. It seems, from other experiments, that ants in difficulties within sight of their companions are by no means always assisted or relieved; other attractions, food and such like, possessing greater interest for them. On putting some specimens under the influence of chloroform, little or no notice was taken of those insensible by their companions, the tendency apparently being to let friends lie, and throw over the edge of the board strangers thus chloroformed. It seems that to get ants properly intoxicated with spirit for experimental purposes is no easy matter, some recovering too quickly and others remaining so thoroughly dead-drunk as to come under the rank of impracticables; while between reeling friends and strangers the experimenter finds himself baffled. The sober ants are exceedingly puzzled at finding their friends in such a condition. As a general rule, they picked up drunken friends and carried them to the nest, while they threw into the water and drowned strangers. In some instances confusion arose, for a few of the strangers were carried to the nest and friends tumbled into the water; but they did not return to the rescue of the friends, though strangers were afterwards expelled from the nest. Sir John expresses surprise that ants of one nest perfectly well know each other. Even after a year's separation old companions are recognized and amicably received; whereas strangers, particularly among the *Lasius flavus*, are almost invariably attacked and maltreated, even when introduced in the mixed company of old friends. Sight cannot be acute. For example: in experiments food was placed on a glass slip a few inches from the nest, the straight road to and from the nest being soon familiar to the ants; but when the food had been shifted only a short distance from its first position, it was long ere it was discovered. Indeed, they wandered from a few minutes to half an hour in the most extraordinary circuitous routes before finding out the direct road between the nest and food, and *vice versa.* Slavery in certain genera is a positive institution—the Amazon ants (*Polyergus rufescens*) absolutely requiring slave assistants to clean, to dress, and to feed them, else they will rather die than help themselves,

though food be close at hand. A curious blind wood-louse (*Platyarthrus Hoffmanseggii*) is allowed house-room by the ants. It acts as a kind of scavenger, the ants taking little notice of the wood-lice, and even migrating, leaving them behind. Some new species of Diptera, of the family Phoridæ, he finds to be parasitic on our house-ants, and Mr. Verral has recently described these interesting forms.

Herr Dönhoff has been experimenting on the flight of bees. He took some bees from the hive just as they came out of the entrance hole, and placed them under a glass bell, at a temperature of 66° Fahr. First they ran hastily up and down the sides of the glass and flew about in the jar. Later on their movements became less hasty, and after forty-five minutes they all sat quietly together, moved slowly and clumsily. They were no longer able to fly about. He let a few crawl upon a pencil, and, by giving it a jerk, threw them into the air. They fell down perpendicularly, without giving a humming sound—*i. e.*, without moving their wings. He killed and opened one or two, and found their honey-bags empty. To the others he then gave a solution of sugar, and after they had fed for about three and a half or four minutes he again threw some into the air. They no longer fell down perpendicularly, but a little farther off, and also moved their wings. A minute afterwards they did not fall down at all, but flew to the window. They had become the same lively insects as before. If the temperature be under 66° Fahr., they lose the power of flying even sooner, and a longer period elapses before it returns after they are fed on sugar-water. In higher temperatures the power returns sooner. Herr Dönhoff thinks it probable "that the bee loses the power of flying because it does not possess the necessary strength to be converted into muscular action, and that this strength returns to its system because in sugar it finds the necessary vital support."

The long-expected work of Dr. Saussure, of Geneva, on American wasps has been published by the Smithsonian Institution. It refers exclusively to the solitary species of North America, including Mexico and the Antilles. Little is said of the interesting habits of these wasps, the work being confined to their classification. In speaking, however, of the mode of nidification of the genus *Montezumia*, he re-

marks that the "*Eumenes* establish for their offspring separate and distinct cells formed of earth. The *Zethus* build their nests composed of aggregated cellules, established commonly in vegetable matters, and fixed upon little branches of trees. The *Odynerus* nidificate in holes in walls, in the stems of plants, etc. The *Montezumia*, finally, construct their houses of many rooms, a little like those of *Zethus*, but very much more massively built — of earth — and stuck against walls or rocks, as are those of the *Sphegides* and some of the mason bees."

The *Demodex folliculorum* is a worm-shaped minute mite, which lives in the sebaceous and hair-follicles of the skin in man and some mammals. M. Mégnin has lately published a full account of it. It is said to be viviparous, the female producing small footless contractile larvæ, without any mouth organs, which shortly after their birth acquire three pairs of short wart-like feet. After a change of skin a fourth pair of legs appear, as well as traces of a beak. After a second change the perfect *Demodex* is produced, but still without the sexual organs, which appear later. Mégnin distinguishes three if not four forms of these parasites, which, however, he prefers to regard for the present as varieties of a single species — *Demodex folliculorum*. The commonest of these appears to be that of the dog (var. *caninus*), which inhabits the hair-follicles of all parts of the body of that animal; a smaller variety (*D. cati*) is found almost solely in the sebaceous glands of the ear of the cat; and a larger one (var. *hominis*) in the follicles of the human face. M. Simon also met with similar parasites in the glands of the margin of the eyelids in sheep (var. *ovis*); but no other writer has ever seen them there. In the dog the presence of these parasites, which occur in great numbers together in the hair-follicles, produces a regular skin-disease or mange; but this does not appear to be transmissible to the human subject.

M. Mégnin has studied certain mites (*Kytodites glaber* Mégnin) which live in the air-sacs and cellular tissue of birds. They are of two kinds, one of perfect form (*Sarcoptes cisticola*), the others vermiform, which are the pupæ of an external mite (*Pterolichus falcigerus* Mégnin). The subcutaneous life of this form tends to preserve the species from complete annihilation resulting from the casting of the feath-

ers between the quills on which the normal form of this mite lives.

The mites and spiders of Kerguelen Land have been described and figured by Rev. O. P. Cambridge in the *Proceedings* of the Zoological Society of London. A new "order" is proposed for a certain mite, but it is doubtful whether it is the type of a higher division than a family.

The recent work of Mr. Andrew Murray on "Economic Entomology" is devoted to the wingless insects, and mainly to mites. It is a most useful book and very fully illustrated. In treating of the cheese-mite, or *Tyroglyphus siro* of Linnæus, it says: "It is usual to hear the flour- and the cheese-mite spoken of by naturalists, described in books, and mounted by microscopists as two different and distinct species; but they are not so. It was Linnæus who commenced the blunder by judging from the two different kinds of food, instead of from the mites themselves, and describing those which he found on cheese as the cheese-mite (*Acarus siro*), those on flour as the flour-mite (*Acarus farinæ*), and those in milk as the milk-mite (*Acarus lactis*). It has also received other names." It was the cause of an attack of dysentery in Rolander, a student of Linnæus. The disease, however, quickly yielded to the usual remedies; but again returned. Linnæus, aware that Barthélemy had attributed the dysentery to insects, which he professed to have seen, advised his pupil to examine his fæces. "Rolander, following this advice, discovered in them innumerable animalcules, which, upon close examination, proved to be mites. It was next a question how he alone came to be singled out by them; and thus he accounted for it. It was his habit not to drink at his meals; but in the night, growing thirsty, he often sipped some liquid out of a vessel made of juniper wood. Inspecting this very narrowly, he observed, in the chinks between the ribs, a white line, which, when viewed under a lens, he found to consist of innumerable mites precisely the same with those that he had voided. Various experiments were tried with them, and a preparation of rhubarb was found to destroy them most effectually. He afterwards discovered them in vessels containing acids, and often under the bung of casks. In the instance here recorded, the dysentery or diarrhœa was thus apparently produced by a species of mite,

which Linnæus thence called *Acarus dysenteriæ*." Among the most singular of all mites are those which live under the skin and on the superficial veins of certain birds. They are, as would naturally be supposed, quite low in their organization. One species lives in the air-cells under the skin of the solan goose, another lives in the bronchial tubes of the common swift of Europe, and another in the air-tubes and lungs of the butcher-bird, another (*Hypoderas lineatus*) in the fatty masses which lie in the arm-pit on the outer margin of the pectoral muscle. *Hypoderas columbæ* is a small maggot-like animal, distinctly visible to the naked eye, and lives in the connective tissue of the skin, on the large veins near the heart, and on the surface of the pericardium of the pigeon. This and allied forms are figured by Mr. Murray.

Dr. Forel has described the habits of a poisonous spider (*Chiracanthium nutrix* of Walkenaer) which lives in the hedges of Switzerland in the autumn. The female spins a very fine and dense silken cocoon as large as a hen's egg, but more or less spherical. It is in this hermetically closed case that the spider places her packet of eggs. If a cut be made in the cocoon, the spider shows her head, opens her large mandibles, and death awaits those that suffer themselves to be bitten. If a living fly be offered to it, it falls dead at the first bite. When the spider has bitten once or twice, its poison, contained in its hollow mandibles, becomes diminished in quantity and less deathly. When it bites a rather large insect, the latter becomes stupefied a few minutes and then entirely recovers. Several years ago Dr. Forel was bitten in the finger by a female. He felt a violent pain in the hand and arm as high up as the elbow. For at least a minute after he felt sick, a cold sweat passed over him, and a friend, who was with him, held him up by the arm and led him into the house. There was no swelling. The general *malaise* and pain in the arm soon dissipated, but the bitten place remained painful for several days. It is a peculiarity of this poison that its effect is sudden and deadly, and of short duration, both in man and in insects. The male wanders near the nest of the female. It is smaller, slenderer, and its jaws are feebler. It is also poisonous, though less so than the female. "I have been twice bitten by it. The pain is severe, but local and transitory. One day I placed a female in the web

of a large spider of another species. The latter immediately threw itself upon the other, enveloped it with threads, and began to feed upon it, when the poisonous species, disengaging its jaws, bit one of the feet of its victor. Immediately it let go and ran away, holding up its bitten leg, which seemed to be paralyzed, and, rubbing it against the threads of its web, in an instant detached it from its body. The large spider, consciously or not, resolved to save its life by amputating its leg. It remained quiet for a while near its web, and then went into it with one leg less. During this time the poisonous spider had extricated herself from the web and ran away. I then threw it back into the web. The other spider darted upon it and again swathed it in silk; but, more prudent this time, it devoured it without being bitten." This is the first account we have happened to meet with of truly venomous spiders, which probably are not so common as is usually supposed. In the Southern States is a species of *Latrodectes*, a large black spider, with a large globular abdomen, which is known to be poisonous and is allied to a venomous species inhabiting Southern Europe.

In a recent paper on the digestive organs of the harvestmen, or Phalangids, Professor Félix Plateau, the eminent Belgian physiologist, claims that the so-called liver of spiders, as well as of Crustacea, is not a true liver, but that its office is the secretion of the principal digestive fluid.

The harvestmen (*Phalangidæ*) of Europe and Western Asia have been revised by Professor T. Thorell in a paper published at Genoa. The paper is of much use to American students, as certain of the genera are represented in this country, particularly in caverns. In this connection we may add that M. Simon, of Paris, has published a list of the cave fauna of Europe, the animals comprising it being chiefly spiders, insects proper, and myriopods.

A second memoir on scorpions by Dr. Thorell, published at Milan, is mainly descriptive, and contains full diagnoses of several Mexican, Californian, Central, and South American scorpions. The species of American *Galeodes*, a spider-like form, have been studied by J. D. Putnam. While eighteen species of this interesting genus have occurred in other parts of the world, two American ones have been described by Say, and it is probable that three others are in existence. They

are confined to Florida and the central and Pacific coast regions of North America.

Allied to the *Galeodes* is a much larger arachnid, the whip-tail scorpion (*Thelyphonus giganteus*), which occurs in New Mexico. Dr. J. F. Broughter, of Fort Craig, N. Mex., says that the insect is poisonous, and sometimes fatally so. It is regarded by the Mexicans as poisonous.

A volume of 455 octavo pages, under the title of "The Rhynchophora of America North of Mexico," by J. L. Le Conte and G. H. Horn, forms No. 96, Vol. XV., of the *Proceedings* of the American Philosophical Society. The species are very numerous, about 10,000 of them being known. The work of Dr. Le Conte upon this group, as evinced by this memoir, as well as earlier papers, indicates unusual originality and sagacity. He studies them from a completely new standpoint; as he regards them not as constituting a single family, but a higher group represented by eleven families. As the weevils are the lowest type of Coleoptera, they are, Dr. Le Conte claims, therefore, the oldest. They comprise a larger number of forms, and have survived greater geological changes, than any other groups of beetles. He finds that among the weevils "form, color, and sculpture in many instances are repeated in tribes which, from their geological distribution and method of life, cannot be supposed to have any immediate genetic derivation." The views of our author as to the origin of species and higher groups are of interest. He says: "I have no theory to propound regarding this very complex system of cross resemblances. They are certainly not the result of mimicry, and probably not of natural selection, or any other name of an idea which has yet been suggested. A deeper insight into the phenomena of organic nature, which may, perhaps, be acquired by our successors, would give us a more reasonable explanation of these resemblances." Appended to the work is a useful list of the works and articles relating to the injurious species of weevils, prepared by Mr. B. P. Mann.

"Among all *Coleoptera* known to science," says Dr. Le Conte, "there is none which has provoked more discordant expressions of opinion regarding its position and relationship than the genus *Hypocephalus*." After an elaborate study of the single species known, an inhabitant of Brazil, which forms

the type of a distinct family (*Hypocephalidæ*), Dr. Le Conte adopts the view that it belongs to a distinct type; but he also goes further, and maintains the opinion that it is still more isolated, and represents a fragment of a very old fauna, to which other forms of beetles might be added, each of which (*Trictenotoma*, *Cupes*, *Rhysodes*, and the *Brenthidæ*) possesses a certain number of characters in common which separate them from all other beetles, and link them together as representatives of the *ancien régime*. "It has been my opinion," he adds, "expressed many years ago, that by the careful study of the existing forms of insects, which, for reasons given elsewhere both by others and myself, contain a greater number of ancient survivals than any other land animals, these ancient survivals could be recognized and separated; so that we would have by this depuration the evolutions of the present geological age more distinctly separated and defined in our systems of classification; and that we would also be able to ascertain their proper connection (ideal or genetic, or both) with those which existed in past time. I now believe, in addition, that the number of these survivals is so great that we shall have a quite respectable mass of material for the partial reconstruction of the insect fauna of past ages, especially if studied in connection with geographical distribution. The material which we can expect to gather from this line of study will be much greater than what may be expected from the rocks, in which the fragments, badly preserved for the most part, afford us very uncertain and usually very modern evidence of little value."

M. Valléry Mayet has succeeded in rearing to the beetle state the larva of *Adelops Delarouzei*, a blind beetle living in the caves of the Eastern Pyrenees. This is an exceedingly interesting fact; for, though Packard has described and figured the larva of the *Adelops* of the Mammoth Cave, no species of this beetle has been actually reared, and the pupa was unknown.

It has been suggested by an anonymous author, in a marginal note found in an old copy of Geoffroy's "History of Insects," that the asparagus beetle (*Crioceris asparagi*) is viviparous. This needs confirmation, for it rarely happens, if at all, that any beetle brings forth its young alive. Still, however, according to M. Reiche, one beetle (*Oreina*) is

known to be viviparous; and it is possible that, while the asparagus beetle usually lays eggs, the development of the young may be so accelerated within the parent that the young are born alive.

The Colorado potato-beetle (*Leptinotarsa decemlineata*) has been not only introduced into Bremen, but *Nature* records its occurrence in a field near Cologne in every stage of development. In the United States it now occurs in abundance as far east as the Kennebec River, Maine.

Some entomological papers of importance appear in the last Berlin *Entomologische Zeitschrift*, especially certain notes on deformities in insects, mostly beetles. In 1875, H. Mocquérys published an account of twenty such cases among beetles.

The so-called "educated fleas" form the subject of a paper in the *American Naturalist* by Mr. W. H. Dall, who states, after an examination of these entomological curiosities, that, in the first place, the fleas are not educated; and, in the second place, "all the performances which make up the exhibition may be traced directly to the desire and earnest efforts of the insects to escape." He explains the manner in which, on the second hypothesis, the different tricks of these "unconscious automata" are performed.

A synopsis of the two-winged gall-flies (*Cecidomyiadæ*), by Messrs. Bergenstamm and Löw, of Vienna, appears in the *Transactions* of the Zoological and Botanical Society of Vienna. It seems, from the numerous citations of German writers, that the Hessian fly is common in various parts of Europe, and is probably indigenous.

For two years past M. Victor Signoret, of Paris, has been publishing, in the *Annals* of the Entomological Society of France, a series of essays on the cochineal insect, as well as all the different species of bark-lice (*Coccidæ*). The eightieth and last part has now been completed, and will probably be published in book form.

The anatomy and histology of the Aphides and bark-lice form the subject of an inaugural dissertation for the degree of Ph.D. in the University of Leipsic, by E. L. Mark, of Hamlet, N. Y.

The nervous system of the *Hymenoptera* (bees, wasps, ants, sawflies, etc.) has been studied by E. Brandt. He de-

scribes certain pedunculate bodies whose development, as originally discovered by Dujardin, corresponds with the degree of development of the instincts and intelligence in the different species. Brandt's researches now enable him to prove that this is the case also for the different sexes of the same species. Thus in the worker of the honey-bee they are of immense size, while they are slightly developed in the queen and in the males.

It has usually been supposed that all the silk-worm moths issue from the cocoon by moistening the threads and pushing through them. This is, however, not the case, says Dr. Packard, with *Actias luna*, a large, handsome, pale-green moth, with long "tails" on its hind wings. His attention was called to a rattling, cutting, or tearing noise issuing from a cocoon of this moth. On looking at the cocoon, a sharp black point was seen moving to and fro, and then another, until both points had cut a slit, through which the shoulders of the moth could be seen. The hole is made in a minute or two, and the moth works its way at once out of the slit. The wings at this time being very small and flabby, the points stick out, and can be used for the purpose indicated. In about an hour after exclusion from the cocoon the wings become fully expanded; but the black points can still be seen through the hairs immediately at the base of the wings. In this case no fluid was seen to exude from the moth, and the cocoon was perfectly dry.

This cutting apparatus has also been found to exist in *Platysamia Cecropia*, *P. Promethea*, *Telea Polyphemus* of the United States, in a Texan *Attacus* and a second species from Nicaragua, and in *Attacus Amazonia* Pack., from Pebas, Peru; also in two European species, *Endromis versicolor* and *Saturnia pavonia-minor*. The spines are feebly developed in *Bombyx mori*, the common silk-worm, which secretes a fluid, softening the threads of its cocoon, and enabling the moth to press through them, though it cuts a few threads.

Dr. Fritz Müller describes a curious instance of commensalism in two larvæ of some unknown *Lepidoptera*. He says the larger caterpillar, which has a red head and is protected from enemies by long-branched white stinging hairs, lives on mulberry and other trees. Like other protected caterpillars, it is light-colored and sits on the upper surface of the

leaves. The second caterpillar is a little blackish fellow, and lies across the back of his larger companion, concealed among the stinging spine-like hairs of the latter. When taken off, he went back to his original place immediately. In order to photograph the two animals, Dr. Fritz Müller stupefied the larger one with ether, which caused its death in about two days. The smaller caterpillar then quitted his post and took up his abode on a second specimen, the place that he had occupied on his former host having a pale and worn appearance. The smaller caterpillar stretches down from his position of vantage among the spines of the larger and eats little holes in the leaf on which the latter rests.

The second part of Mr. A. R. Grote's check-list of the *Noctuidæ* of America north of Mexico has appeared, and will prove of much use to entomologists in arranging their collections.

A new tenant of the nests of a species of ant (*Formica subsericea* Say) has been found in the caterpillar of some species of *Lycænidæ.* "The lower segments of the abdomen were continually gently stroked by the antennæ, in the familiar manner of ants when soliciting honey-dew from Aphides." Mr. W. H. Edwards has found that the caterpillar of *Lycæna pseudargiolus* is possessed of organs upon the upper part of the last segments apparently designed or fitted for the exudation of some fluid, as also shown by Dr. Leidy in some specimens received from Mr. McCook.

"Insects," says Professor J. Plateau, "are often attracted from a distance by artificial flowers, but never alight on them." They must, therefore, he thinks, be guided by some other sense besides that of sight.

Several new genera and species of bird-mites are described and figured by Heller in Siebold and Kölliker's *Zeitschrift.*

Professor C. V. Riley has studied the transformations of the locust-mite (*Trombidium locustarum* Riley) which attacks grasshoppers, and lives from the Atlantic coast to California, but is especially abundant on the Rocky Mountain locust. In spring the female lays between 300 and 400 minute, spherical, orange-red eggs in the ground. The young *Trombidium* when hatched has but six legs. In this form, and when very small, they creep on the locust and adhere to the base of the wings, where they become swollen and oblong in form, until finally they let go their hold and drop

to the ground, where they remain quietly for two or three weeks, gradually swelling and changing form. "At this time the pupa state is assumed, but not by shedding any skin, as do true insects in undergoing their transformations. New legs, feelers, and mouth-parts form under the old skin, which, with its now useless legs, distends so as barely to cover the new parts, which are all appressed to the body, very much as in the pupa of a beetle." Finally, both the distended larval skin and the new one that incases the pupa burst, and release the mite in its eight-legged adult form. It appears that from the time this mite hatches, through all its growth and changes, but one molt takes place. The adult mite passes the winter in the ground, and is active whenever the temperature is a few degrees above freezing-point. Professor Riley has also reared *Trombidium muscarum* Riley from the larva which lives on the common house-fly. He also figures and describes the transformations of *Hydrachna belostomæ* Riley, an aquatic mite which usually infests the large water-bug (*Zaitha*); as many as 500 sometimes occurring on a single bug. They fasten themselves and penetrate the chitinous skin of their host with their maxillæ, which form a long, pointed thread. The body becomes sac-like, and transforms into the pupa state within this sac, which finally bursts to release the adult mite. This bag-like larva was looked upon as an egg by many old authors, and was made the type of the genus *Achlysia* by Audouin. Mr. Riley's article is printed in advance from the *Report* of the United States Entomological Commission.

The development of the crayfish has been freshly studied by Reichenbach, who supplements the works of Rathke, Lereboullet, and Bobretsky. He has found that many of the endodermal cells of the ordinary columnar form are lobed at the end towards the yolk, and give off more or less fine threads of protoplasm, which pass between, and in some cases surround, the yolk spheres. These cells evidently absorb the nutritive matter of the yolk, "not by a passive process of diffusion, but by an active process of ingestion, the food particles being immediately 'plunged into the living protoplasm of the cell,' and there digested." This active swallowing of particles of the yolk by embryonic cells was first observed by Lankester in the egg of the cuttle-fish.

The mode of moulting of the integument and lining of the crop and proventriculus, or fore-stomach, of the *Orthoptera* has been studied by Wilde. On the histological processes in the moulting of animals in general we have the previous works of Cartier, Braun, and Kerbert. In the reptiles as well as in the *Astacus*, or crawfish, moulting of the skin is effected by its being pushed off, in the first place, by fine cuticular hairs, which afterwards disappear. Exceptions to this mode only occur in the reptiles on certain parts of the body, as, for example, on the underside of the scales and the capsular skin of the eyes of reptiles; in the *Astacus*, the faceted cornea, the eye-stalk, and the inner lamellæ of the fold of the carapace over the gill-opening. In the locusts and grasshoppers the teeth arming the crop and fore stomach, though primarily of use in triturating the food, especially in the crop, are secondarily useful in loosening the cuticle lining those parts of the digestive canal. As soon in the *Orthoptera* as the old cuticle is loosened and stripped off, there is the new cuticle completely formed under it. It is at first completely transparent, but takes on, after a few days—probably through the influence of the air, which passes through very fine tracheal twigs under the layers of epithelium—the characteristic yellow-brown color of the chitine. The secretion of the new cuticle must follow with great rapidity. It does not take more than one or at least two days in developing.

BOTANY.

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There has been a very general activity during the present year on the part of botanists, as is shown by the large number of papers published in the different journals; although it would seem that the number of published books, particularly of those relating to flowering plants, was smaller than usual. As has been the case for some years past, the work done in Germany has been largely physiological and developmental, while in England and this country descriptive botany has been almost exclusively studied. During the year an unusual number of prominent botanists have died, of whom a considerable proportion were still in their prime, so far as activity in botanical pursuits was concerned. It is seldom that in one year four such prominent names as those of Alexander Braun and Hofmeister in Germany, and De Notaris and Parlatore in Italy, disappear from the ranks of botanists.

GENERAL.*

Phænogams.

In striking contrast to what is usually the case, there is but little to be recorded in the department of descriptive phænogamy. The "Flora Brasiliensis" has been continued, one volume being devoted to the *Gramineæ*, comprising the suborder *Paniceæ*. The "Dictionnaire de Botanique," conducted by Baillon, has also been continued by a second part, comprising several different orders. The *Proceedings* of the Linnæan Society include a number of short articles on phænogams, the principal of which is an account by J. G. Baker, of the *Irideæ*. The *Journal of Botany* contains also a number of short articles, among which may be noticed "Descrip-

* The special report with regard to botany in America will be found on page 333.

tive Notes on a Few of Hildebrandt's East African Plants," by J. G. Baker and S. Le M. Moore; and "New Palms Collected in the Valley of the Amazon in North Brazil in 1874," by J. W. H. Trail. The *Botanische Zeitung* contains an article by Dr. Robert Caspary, in which he describes a new species of *Nymphæa*, *N. Zanzibarensis*, and gives a synopsis of the species of the genus found in tropical Africa. In the same journal a new "Classification of Palms," on the somewhat novel basis of geographical distribution is given by Drude. A third part of the "Prodromus Floræ Hispanicæ," by Willkomm and Joann, has appeared; and Beccari has published, at Genoa, observations on some of the plants collected by him in the Malay islands.

Vegetable Anatomy and Physiology.

Several important contributions have appeared during the year on this subject. First, in importance as well as size, is the "Comparative Anatomy of the Organs of Vegetation of Phænogams and Ferns," by Professor De Bary, of Strasburg. The work consists of over six hundred pages, with a large number of wood-cuts, and is the most elaborate treatise on the subject since the days of Von Mohl. This volume is the third of the series entitled "Manual of Physiological Botany," published by Hofmeister in connection with De Bary and Sachs. Owing to the death of Hofmeister and other causes, it is announced that the work will not be carried further. The Botanical Laboratory of Würzburg has shown great activity, and several interesting papers have been published by Professor Sachs and his pupils. The most important article of this series is an essay on the "Arrangement of the Cells in the Youngest Parts of Plants." The paper is accompanied by diagrams, the object of which is to show that, whether the terminal growth takes place by means of what is generally known as a *Scheitelzelle*, a single terminal cell, or by a membrane, the cells are so arranged that a series of curves can be drawn through them in such a way as to have a common focal point, and to bear a definite relation to certain hypothetical axes. In those cases where the growth is by a single terminal cell, Sachs thinks that the growth is not highly developed, but the contrary. Sachs has also a paper on the porosity of wood, in

which he shows that the discoid markings of the spring and a part of the autumn wood are closed by a membrane, as was maintained by Sanio and Hartig. Vesque, in the *Annales des Sciences*, states, in an article on "Water in the Stems of Ligneous Plants," referring to a paper by Geleznow, that in some plants the wood is drier than the bark, and in other cases just the reverse; and the relative dryness depends upon what he styles the "transpiratory reserve."

The anatomy of the root is treated in a paper by Holle, on the "Growing-point of the Roots of Dicotyledons," in which he takes certain exceptions to the classification of roots according to their anatomical structure, as advanced by Janczewski in the *Annales des Sciences.* Absorption is treated by Vesque in a paper in the *Annales des Sciences*, in which he calls to mind the difference between exhalation and respiration. In the study of the crystals and albuminoids of plants, we would mention the discovery by Kraus of inulin in orders other than the *Compositæ*, in which it was previously known to exist. Kraus notices its occurrence in several species of the orders *Campanulaceæ*, *Lobeliaceæ*, *Goodeniaceæ*, and *Stylideæ.* Harz has discovered in the testa of *Spergula vulgaris* and *S. maxima* a new fluorescent substance, to which he gives the name of *spergulin.* Anatomical studies in relation to limited groups are furnished in the papers of Koch on the "Development of the Seeds of the *Orobanchaceæ*," and by Kamienski on the "Development of the *Utriculariæ*," the former of which appeared in Pringsheim's *Jahrbuch*, and the latter in the *Proceedings* of the society at Warsaw.

The work of Darwin on the "Effects of Cross- and Self-fertilization in the Vegetable Kingdom," although in reality published in 1876, has not generally reached the public until the present year. It is giving it the highest praise in saying that it is not inferior to any of his previous works in thoroughness and scientific precision. From the mass of details which it contains, it is not likely to be thoroughly read by the public, who will be satisfied with the review of the work given by Professor Gray in the *American Journal of Science* for February, or that in the *Journal of Botany* for March. The careful tabulation of accurately conducted investigations shows the decided advantage possessed by cross-fertilized plants. Of course, the book has given rise to violent discussions; but

nothing has yet been adduced to detract from the correctness of Darwin's conclusions. In connection with this subject, we would refer to a work by Hanstein and A. Braun on the parthenogenesis of *Cœlebogyne ilicifolia*, in which, as we understand, Hanstein thinks the parthenogenesis is proved. The subject of Insectivorous Plants has been discussed in numerous papers, among which we may mention an article by Batalin in *Flora* on the "Mechanism of the Motions of Insectivorous Plants." It is evident, however, that the cream of the subject is to be found in Darwin's work on the subject; and the articles which have lately appeared are beginning to seem a little drawn out. A son of Mr. Darwin has made observations on the protoplasmic filaments protruded by the hairs of *Dipsacus;* and Cornu, in the *Comptes Rendus*, mentions having seen the protoplasmic contents of a cell in a fungus pass directly through the cell-wall.

Ferns and Mosses.

Systematic works on the higher cryptogams have not been very abundant during 1877. Cesati, in the *Proceedings* of the Neapolitan Academy, has two papers on the higher cryptogams of Borneo and some Polynesian islands. J. G. Baker describes some ferns of the Andes in the *Journal of Botany;* and Professor Harrington, of Michigan University, describes some new species collected by Professor Steere. Perhaps the most important general work on higher cryptogams published during the year is the "Cryptogamic Flora of Silesia," under the direction of Professor Cohn, of Breslau. The vascular cryptogams are arranged by Dr. Stenzel, the mosses and liverworts by Dr. Limpricht, and the *Characeæ* by the late Professor A. Braun. The latter portion is particularly worthy of commendation. A second volume, including the algæ by Cohn, and fungi by Dr. Schroeter, is said to be in press. In *Flora*, Dr. Franks has a paper on the mosses of the northern part of Bavaria, and Jach has an article on *Hepaticæ* in the *Botanische Zeitung*, in which he criticises the views and determinations of Dumortier.

In regard to the development and morphology of the higher cryptogams, there have been several interesting discoveries. Dr. Berggren, of Lund, has published in the *Botaniska Notiser* a preliminary notice of the germination of

Azolla, studied by him in New Zealand. Although long studied, the mode of germination of *Azolla* (which, according to Dr. Berggren, resembles that of *Pilularia*) had escaped detection. Stahl, in the *Botanische Zeitung*, describes the process by which the stalks of the spore-cases in mosses, when cut across, may produce protonemata. The same subject is more elaborately treated by Pringsheim in his *Jahrbuch;* and he gives, in concluding, his views of the nature of the prothallus in the higher cryptogams. Leitgeb has continued his researches on the morphology of *Hepaticæ*, to which, for some years, he has paid special attention.

Fungi.

On no branch of botany is the annual literature more voluminous than on this. The magazine articles in which new species have been described are far too numerous for special mention. In *Hedwigia* articles have appeared by Magnus, Schroeter, Von Thümen, Niessl, and others; and in *Grevillea* by far the larger number of articles by English botanists relate to fungi. In the *Annales des Sciences* is a series of mycological essays by Sorokin, who has also published something in *Hedwigia.* In England, a translation of Rostafinsky's "Myxomycetes," at least so far as the British species are concerned, has been made by M. C. Cooke. The first volume of Fries's "Icones Hymenomycetum" has been successfully finished. A useful synopsis of the *Ustilagineæ*, by Professor Fischer von Waldheim, has been published in the *Annales des Sciences;* and the same author has also distributed a paper on the species of *Entyloma*, and a list of the plants on which the species of *Ustilagineæ* are parasitic. Dr. Wilhelm, of Strasburg, has also distributed his doctorate thesis on the species of *Aspergillus.* Special mention should be made of some developmental works on fungi. Brefeld's *Basidiomycetes* forms the third part of his series published under the name of "Ueber Schimmelpilze." Brefeld is the strongest advocate of the view that, so far as at present known, the fruit of the *Basidiomycetes* is not produced from a carpospore. In a short article, Brefeld also discusses the theory that fungi do not require light to attain perfection, and brings forward several facts to show that such is not the case—at least, not universally; for some species will not bear

spores until they are exposed to the light. In a paper on the species of *Entomophthora*, the same writer states that the fungus described by Cohn, in the "Beiträge zur Biologie," under the name of *Tarichium* is only the resting-spore stage of *Entomophthora radicans*. In concluding, he presents a new view of the classification of fungi, which, while some will complain of it as being too speculative, is in some respects an improvement on the ordinary classification. Dr. Hermann Bauke, in a thesis on the "Nature of Pycnidia," shows, by means of cultures, that the view of Tulasne was in the main correct, and that the pycnidia are in most cases states of different *Sphæriaceæ*, although he admits there are a few cases where the reverse is the case. "The Nature of Spermatia" has formed the subject of a paper by Cornu in the *Annales des Sciences*. He denies that the *spermatia* are male organs, because he has succeeded in making them germinate, which, as he thinks, proves that they are forms of stylospores. The low group of fungi (or, if you please, algæ) the *Chytridiaceæ* has of late been a favorite field of study; and new species and genera are described with uncomfortable frequency. In the second part of Volume II. of the "Beiträge zur Biologie," Dr. Nowakowski describes a new species, *Polyphagus euglenæ;* and Sorokin, in the *Annales des Sciences*, has a paper on the vegetable parasites of the *Anguillulæ*. The subject of fermentation has been studied by Brefeld in a third paper, in which he states that *Mucor racemosus* and *M. stolonifer* produce alcoholic fermentation, although to a much less marked degree than the yeast plant.

Lichens.

New species of lichens have been described by Crombie in England, and by Nylander and Arnold on the Continent. The discussion as to the nature of lichens has been carried on by Winter and Minks in the different numbers of *Flora*, and Nylander has in the same journal some notes on the different forms of Gonidia. The discussion between Drs. Winter and Minks is acrimonious and even abusive, and the botanical public can hardly be said to feel much interest in this personal matter. A very important paper, in two parts, has been published by Dr. E. Stahl. In the first part, the structure of the organs of fructification in lichens is discussed.

Stahl regards the *spermatia* as male organs, in opposition to the view of Cornu above stated, and he finds them attached to a trichogyne-like organ. This is confirmed by Mr. George Murray in the case of *Collema pulposum* in the *Journal of Botany*. Stahl believes that the process of fertilization in lichens is very similar to that in the *Florideæ*, or red sea-weeds. In the second part, Stahl relates his experience in cultivating lichens from the spores in connection with free gonidia. The species studied were *Endocarpon pusillum*, *Thelidium minutulum*, and *Polyblastia rugulosa*. The first two species Stahl was able to cultivate until they produced new spores. He also succeeded in making *Thelidium* grow upon the gonidia of *Endocarpon*. This is the first successful attempt to produce the fruit of a lichen by sowing the spores with gonidia; and Stahl's experiments go far towards strengthening the view of Schwendener that lichens are fungi parasitic on certain algæ. It is announced that hereafter, in Just's *Jahresbericht*, the lichens will not be kept as a separate department, but merged with the *Ascomycetes*.

Algæ.

A paper by Dr. Wittrock on the "Development and Systematic Arrangement of the Pithophoraceæ" gives the characters of an order of green algæ, which closely resemble the *Cladophoræ*. A series of papers by Dr. Kjellman on the algæ of Spitzbergen, Nova Zembla, and other northern regions is an important contribution to our knowledge of the arctic marine flora. In Nova Zembla, Dr. Kjellman remarks the almost entire absence of a litoral vegetation. Algæ from the Adriatic have been described by Hauck in the Austrian *Journal of Botany*. A well-prepared set of algæ, principally fresh-water, from Sweden, by Nordstedt and Wittrock, has been offered for sale. In the way of development of algæ we have to mention a careful paper by Janczewski, in the *Proceedings* of the Cherbourg Society, on the "Development of the Cystocarp in Florideæ." The development of *Botrydium granulatum* has been studied by Rostafinsky and Woronin, and it is described and figured in the *Botanische Zeitung*. This plant finally produces zoospores with two cilia which conjugate with one another; but there are also, in some stages, zoospores which do not conjugate. The de-

velopment of *Acetabularia Mediterranea*, which was only partially known, has been completed by Professors De Bary and Strasburger. The bodies which were called spores are shown to produce zoospores, and a peculiar basal process of the thallus is described. Reinke, in Pringsheim's *Jahrbuch*, has described the growth of the thallus in certain *Phæosporæ*, and has also studied the development in *Zanardinia collaris*, where, as he says, the mass which is to form the spore comes to rest before being fertilized. A somewhat acrimonious discussion has appeared in the columns of the *Botanische Zeitung* between Reinke and Rostafinsky with reference to the credit to be assigned to their different papers on the terminal growth of Fuci, reported in last year's *Record.*

Bacteria.

The literature of *Bacteria* and related forms has not been quite so voluminous as last year. A substantial paper, by Warming, has appeared in the Copenhagen *Proceedings*, in which there are described and figured several of the Danish monads, *Bacteria*, *Beggiatoæ*, etc. The investigations of Tyndall with regard to the sterilization of liquids have been important. Sterilization, or the reduction to a state of inactivity or torpidity of the germs of minute vegetable organisms, is, according to Tyndall, better accomplished by repeatedly raising the fluid to the boiling-point, and allowing it to remain there but an instant, than by prolonged boiling.

In General.

The changes which have taken place in the botanical chairs have been more numerous than usual the present year. The deaths of Alexander Braun, Hofmeister, De Notaris, and Parlatore left vacancies in the chairs of Berlin, Tübingen, Rome, and Florence. The chair of Berlin has been filled by Eichler, of Kiel. At Tübingen, Professor Schwendener, of Basle, replaces Hofmeister; and Pfeffer, of Bonn, is transferred to Basle. At Florence it is reported that Beccari is to have the chair filled by Parlatore. Professor J. E. Areschoug, of Upsala, having resigned, his place has been filled by Professor T. M. Fries. The chair of Aberdeen having become vacant by the resignation of Professor Dickie, Mr. J. W. H. Trail has been appointed in his place. Millardet, formerly of

Nancy, has recently been appointed to a position at Bordeaux. Rostafinsky has been promoted to a professorship at Cracow. During the year, no botanical expedition of importance has been undertaken. Among the changes which are worthy of note is the erection of a new building for the herbarium at Kew, which, as we learn from the last report of the director, is estimated to contain considerably over a million specimens. There has also been erected at Kew a laboratory for the pursuit of physiological studies.

PROGRESS IN AMERICA.

Descriptive.

In America, the botanical publications have been principally confined to articles in the different journals. In systematic botany we have to note three papers by Professor Asa Gray in the *Proceedings* of the American Academy. The first, which appeared late in December, 1876, but which was not generally distributed until the beginning of the present year, is a description of the two genera of *Papaveraceæ* (*Canbya* and *Arctomecon*), both from California, illustrated by two plates by Sprague. The species of *Arctomecon* has a persistent instead of a caducous corolla, as is usual in the order to which it belongs. The second paper, which bears the same date as the first, contains the descriptions of new species of several different genera, including a synopsis of the North American species of *Asclepias* and allied genera. In this paper, the genus *Steironema* of Rafinesque is restored, and several species separated from *Lysimachia*, where they had been previously placed. A third paper, by Professor Gray, in the *Proceedings* of the American Academy, bearing the date of May, 1877, contains a description of the new genera—*Sympetaleia* of the *Loasaceæ*, and *Lemmonia* of the *Hydrophyllaceæ*, both belonging to California; besides revisions of *Canotia*, Torr.; *Echidiocarya*, Gray; and *Leptoglossis*, Benth. Mr. Sereno Watson also contributed to the same *Proceedings* a paper, bearing the date of June 13, in which he described a number of new species, and gave revisions of the genera *Lychnis*, *Eriogonum*, and *Chorizanthe*. In the *Transactions* of the Academy of Science of St. Louis, Dr. George Engelmann continues his account of the oaks of the United States.

He also contributes two other papers—one on the American junipers, and the other on the flowering of *Agave Shawii*, illustrated by a plate. The second fasciculus of the "Wild Flowers of America," plates by Mr. Isaac Sprague and text by Professor G. L. Goodale, has appeared, and includes four species — *Iris versicolor*, L.; *Rudbeckia columnaris*, Pursh; *Viola sagittata*, Aiton; and *Steironema lanceolatum*, Gray. The drawing of the first-named species is one of the finest ever made in this country. There is announced as about to appear a series of plates of native flowers, with text by Professor Thomas Meehan, of Philadelphia, the lithographs being furnished by Prang, of Boston.

In the department of cryptogams we must note an elaborate paper, by Professor Edward Tuckerman, on North American and other lichens, published in the *Proceedings* of the American Academy. The species described, besides those found in the United States, were collected by Dr. Hill during the Hassler Expedition. In an appendix are given the species collected by Dr. J. H. Kidder at Kerguelen Land during the Transit of Venus Expedition. New species of American fungi have been described in various publications. We may particularize, in this connection, articles by J. B. Ellis and Baron von Thümen in the *Bulletin* of the Torrey Club; by W. R. Gerard in the *Proceedings* of the Poughkeepsie Society; by M. C. Cooke in the *Bulletin* of the Buffalo Society, where a synopsis of American species of *Hyphomycetes* is given; also articles by the same botanist in *Grevillea;* and, lastly, by C. H. Peck in the twenty-seventh and twenty-eighth reports of the Botanist of the State of New York for the years 1873 and 1874 respectively. The two last-named reports are illustrated by plates of fungi, and not only contain accounts of the fungi and other cryptogams of New York State, but also notes of newly discovered localities of flowering plants. Californian species of fungi, principally from the collections of Dr. Harkness, have been given by Plowright, Philips, and Rev. Mr. Vize in *Grevillea.* Additions have been made to the marine flora of the United States in a paper by W. G. Farlow published in the *Proceedings* of the American Academy of Boston. In the same *Proceedings* Professor D. C. Eaton describes a new species of *Nitophyllum.* There has also appeared the first fasciculus of a set

of algæ of the United States, prepared by Professor Farlow, Dr. C. L. Anderson, and Professor D. C. Eaton. In the higher cryptogams there have been new species of mosses and *Hepaticæ* described by C. F. Austin in the Torrey *Bulletin*, and an illustrated paper on some ferns of the Western country has been prepared by Professor D. C. Eaton for the report of the Wheeler Expedition. The first set of a series intended to include all the species of ferns found in the United States—the text by Professor D. C. Eaton, and plates by Mr. Emerton—has appeared, and the execution is all that could be desired.

Physiological.

It is a subject of congratulation that the number of articles on vegetable physiology and the minute anatomy and development of different groups is increasing in this country; and there seems a probability that, at no distant date, important work in this department will be done by American botanists. As might be supposed, the interest of our botanists has been especially turned to the subjects of cross-fertilization and insectivorous plants. On the former subject, notes have been published by Professor Gray, in the *Naturalist*, on the fertilization of *Gentiana Andrewsii*, which, he thinks, is generally fertilized by insects, although occasionally it is self-fertilized. In the Torrey *Bulletin* the same opinion is advanced by Mr. W. W. Bailey. On somewhat insufficient grounds another writer, in the same journal, considers the flowers of *Gentiana Andrewsii* as cleistogenic. In the *Naturalist* for May, Mr. H. G. Hubbard relates his observations on *Aristolochia clematitis*, made while travelling in Jamaica. The flower, which is shaped like a German pipe, is divided into three chambers, by constrictions and valves, furnished with backward-pointing bristles, the whole forming a trebly guarded fly-trap. The outer chamber alone gives out the carrion odor which attracts insects to enter, and these cannot escape on account of the backward-pointing bristles. Mr. Hubbard shows, however, that, as the flower withers, the constrictions disappear, and the insects readily escape, loaded with pollen. In the same journal, a review of the literature with regard to the cleistogenic flowers of different species of *Viola* is given by Professor Goodale. With regard to the insectivorous properties of *Sarracenia*

variolaris, Dr. J. H. Mellichamp, of Bluffton, S. C., has made experiments which show that the sweet secretion of that plant acts simply as a lure, and has not, as some have supposed, an intoxicating effect on the insects which feed upon it. The observations of Dr. Mellichamp were confirmed by Mr. B. M. Watson, of Cambridge. Professor C. E. Bessey has published, in the *Naturalist* of August, the result of some careful experiments to ascertain the cause of the peculiar position which the leaves of the *Silphium laciniatum* (compass plant) assume. The first gives tables of the variation from a line passing north and south which he observed in plants of different ages and sizes; and the comparatively slight variation from the meridian is quite striking. In seeking for the cause of the peculiar position of the leaves, he finds that the relative position of the stomata on the upper and under surfaces of the leaf does not determine the real cause of the polarity. In a later note, Professor Bessey states that, what is known as the "palisade tissue," which is usually found only on the upper surface of the leaf, is in *Silphium laciniatum*, distributed throughout the whole leaf.

In General.

During the past year no new botanical work has been attempted in connection with the different Western surveys; although it is understood that progress has been made by Professor Rothrock in working up the plants collected by him during a previous expedition. We must not, however, omit to mention the botanical work by Professor Macoun in connection with the survey of Canada. An event of interest has been the visit to this country of Sir J. D. Hooker, who, in company with Professor Gray, Professor Leidy, and others, spent nearly three months in the Rocky Mountains and California. In the way of new publications we would mention the first *Bulletin* of the Illinois Museum of Natural History, containing botanical articles by Fred. Brendel, M.D., and T. J. Burrill; and also a volume of the *Proceedings* of the Ann Arbor Scientific Association, containing articles by Mr. V. M. Spalding and Miss Almendinger. During the year very little change has taken place in the management of the botanic gardens, or the botanical chairs, in the country. Dr. J. T. Rothrock has been appointed Professor of Botany in the

University of Pennsylvania, and Professor Thomas Meehan has accepted a similar position in the Agricultural College of Pennsylvania. W. R. Dudley, of Cornell, has been promoted to the position of Assistant Professor of Botany; R. W. Greenleaf has been appointed Assistant in Botany at Harvard, and B. M. Watson, Jr., Instructor in Horticulture at the Bussey Institution.

MISCELLANEOUS NOTES.

Classification of Palms.

In the *Botanische Zeitung*, Dr. O. Drude proposes a modified classification of the palms, the basis of which is the separation of the New and Old World forms, based upon the facts that no species of palm is indigenous both in America and the Old World; no genus is common to both worlds; and even the tribes are almost limited by the same laws of distribution. The arrangement is briefly as follows:

1. *Calameæ.*—Tropical Africa, Asia up to 30° N. lat., the Sunda Isles, and Australia to 30° S. lat.
2. *Raphieæ.*—Equatorial Africa, Madagascar, Mascarenes, and Polynesia.
3. *Mauritieæ.*—Tropical America from 10° N. to 15° S. lat.
4. *Borassinæ.*—Africa, Mascarenes, Seychelles, and Western Asia to 30° N. lat.
5. *Cocoineæ.*—America, 23° N. to 34° S. lat.
6. *Arecineæ.*—All around the world from 30° N. to 42° S. lat.
7. *Chamædorineæ.*—America, 25° N. to 20° S. lat.; Madagascar, Mascarenes, and Seychelles.
8. *Iriarteæ.*—America from 15° N. to 20° S. lat.
9. *Caryotineæ.*—Asia to 30° N. lat., Sunda Isles, Australia to 17° S. lat.
10. *Coryphineæ.*—All around the world from 40° N. to 35° S. lat.

Roots of the Banian Tree.

The most remarkable evidence of the extraordinary power of the pendent roots of the banian has been lately exhibited in the celebrated temple of Juggernauth. The great Hindoo temple of Juggernauth is notorious throughout the world. Built at a cost of half a million sterling, it is black with age.

After seven centuries, this sacred edifice, which has defied the elements and encroachments of age, has been suddenly found to be on the verge of destruction. The seeds of the banian and peepul tree have got under the foundations; the whole fabric has been loosened. The ruin was first indicated by the fall of some large stones, just after the idols had left the temple on the last car-festival. Had they fallen a few minutes before, they would have been smashed to atoms. This catastrophe has, as may be imagined, caused great consternation, and is likely to have a disastrous effect on the prestige of the great Juggernauth. It is a curious coincidence that the most celebrated Hindoo temple should have been thus undermined by trees held sacred, if not divine, by the whole Hindoo nation.

History of Helianthus Tuberosus, or Jerusalem Artichoke.

The question as to the country from which the Jerusalem artichoke originally came has been the subject of a correspondence in the *American Journal of Science* between Professor Gray and Mr. J. H. Trumbull. Linnæus, in the "Species Plantarum," gave to *Helianthus tuberosus* the "habitat in Brasilia." In his earlier "Hortus Cliffortianus" the habitat assigned was Canada. De Candolle, in his "Géographie Botanique," refers to this as "decidedly an error— at least as to Canada properly so called"—and assigns good reasons for the opinion that it did not come from Brazil, nor from Peru, but in all probability from Mexico or the United States. In the second edition of the "Manual of Botany of the Northern United States," Professor Gray stated that in his opinion *H. doronicoides* of the Western States was most probably the original of *H. tuberosus.* Mr. Trumbull, after quoting several instances where the Jerusalem artichoke is reported as coming from Canada, says, "The notices by early voyagers of ground-nuts eaten by the Indians are generally so brief and so vague that it is not easy to distinguish the three or four species mentioned under that name or its equivalents. The *Solanum tuberosum*, *Apios tuberosa*, *Aralia trifolia*, and a *Cyperus* were all "ground-nuts" or "earth-nuts." Brereton, in his account of Gosnold's voyage to New England in 1602, notes the "great store of groundnuts" found on all the Elizabeth Islands. They grow "forty together on a string, some of them as big as a hen's egg."

These doubtless were the roots of *Apios tuberosa.* But when Champlain, a few years later, was in the same region, he observed that the Almauchiquois Indians near Point Mallebarre (Nausett Harbor probably) had "force des racines qu'ils cultivent, lesquelles ont le goût d'artichaut." Sagard-Théodot mentions the cultivation of the sunflower by the Hurons, who extracted oil from its seeds; and he adds that the French called them *Canadiennes,* or *pommes de Canada.* As to the annual sunflower said by Linnæus to come from Peru and Mexico, Professor Gray thinks that its original is *H. lenticularis* of Douglas, which again is probably only a larger form of *H. petiolaris* of Nuttall, natives of the western part of the Mississippi valley and of the plains to and beyond the Rocky Mountains.

Living and Fossil Oaks of Europe Compared by De Saporta.

Before the end of the Miocene, Europe possessed oaks which closely resembled *Quercus cerris.* They had cupules of the same kind as the one now living, and the fruit matured in the second year. Three species in Auvergne belonged to the type of *Quercus robur,* and "did not differ from the forms of this group more than these forms differ from one another." *Quercus pedunculata, sessiliflora,* and *pubescens* are relatively recent. In the middle of France, at least, these races have been preceded by other oaks, which have since partly disappeared and partly have been confined to a region farther south. On the other hand, species which now occupy only limited stations where they are threatened with extinction, like *Quercus cerris* in France, appear to have had direct representatives there at at an epoch relatively remote (*Naturalist,* April, 1877).

Rapid Growth of Fourcroya.

From Regel's *Gartenflora* we learn that the *Fourcroya gigantea* which recently flowered in Munich attained a height of about twenty-one feet; and of this it made nearly half during the month of October. The greatest elongation in twenty-four hours was 6.3 inches, in a day temperature of 92.75° and a night temperature of 56.75°. No particulars are given respecting the period of the twenty-four hours in which the maximum intensity of growth took place. At the

beginning of October it was about ten feet high, and by the 16th it had increased nearly eight feet, or at the rate of about six inches per day. After this date, with a much lower temperature day and night, the rate of growth was much slower.

Exhalation in Lichens.

According to Godlewski, lichens, or at least *Borrera ciliaris* (the one employed in the experiments) in darkness use up all the oxygen of the air, and exhale carbonic acid; and they form no other gas until there is available oxygen. The intensity of respiration increases with the temperature. In twenty-four hours they will appropriate about their own volume of oxygen, when subject to a temperature of 62.6° Fahr.

Vitality of Grain.

At the meeting of the Linnæan Society on January 18, 1877, R. Irwin Lynch exhibited a pot of growing wheat sprung from grain left in Polaris Bay, Smith's Sound, 80° 83′ N. lat., by the American Polaris Expedition. Captain Sir G. Nares, on his return from the recent Arctic Expedition, in a letter to Dr. Hooker, mentions that the grain in question lay exposed to all the rigorous and intense cold of that far northern clime, through the years from 1872 to 1876. Nevertheless, when the sample brought home was sown at Kew, about sixty-four per cent. of the grains were capable of germination. Two peas were also found to be in good condition. It is likewise worthy of remark that among the wheat a single grain of maize was observed; and this representative of a tropical vegetation retained its vitality in spite of the low temperature, and was among the seeds that germinated. This observation as to the retention of the vitality of seeds is valuable as an authenticated record that the severest arctic frost, even long continued, does not wholly deprive the embryo of the above cereals of its vitality (*Brit. Jour. Bot.*, April, 1877).

Fluorescence of Calycanthus.

A decoction of the bark of the *Calycanthus floridus*, also known as "sweet shrub," is strongly fluorescent. My attention was recently drawn to this fact in examining a mixture of the bark in glycerin, which I had prepared in order to

extract the pleasant odor of its essential oil. The vial containing the bark and glycerin, when looked at askance, emits a rich, bluish shimmer. On comparing a decoction of the bark of this shrub with that of *Æsculus*, or buckeye, by concentrating the sun's rays with a lens into a cone of light passing through the liquids, I discovered that the *Calycanthus* decoction is strikingly superior in intensity and purity of blue color in the fluorescing cone to the *Æsculus* decoction (Robert Toombs, M.D., Washington, Georgia).

The Effect of Frost on Chlorophyl Granules.

Haberlandt states that the granules, except in evergreens, undergo changes at 4° to 6° C. The granules thus affected contain cavities (vacuoles), become rent on the outside, and aggregate into larger or smaller masses. The granules which contain starch are more easily destroyed by frost than those which contain none. The chlorophyl in the palisade tissue (the denser parenchyma) is more easily injured than in the spongy tissue, and the latter than in the guardian cells of the stomata (*Naturalist*, March, 1877).

Effect of Frost on Evergreen Leaves.

This is the question which M. Mer has been striving to answer; and from his paper in the *Bulletin* of the Botanical Society of France we gather that in some cases, as in ivy, the leaves may exist on the reserve stores accumulated in the stem without themselves assimilating any food from the air. In other cases they form starch in their tissues; and if this be not always readily found, the explanation is to be sought in the circumstance that it is transferred to the store-cells in the stem as soon as formed. M. Mer divides the tissues of the leaf into two groups, the office of the one being to assimilate, that of the other to store the food formed by the former.

The Wood-Oil Tree.

According to a recent report from Chittagong, it seems that there is great danger of the wood-oil or gurjun-oil trees (*Dipterocarpus turbinatus*) becoming, in course of time, exterminated. These gurjun-oil forests are described as occupying the outer hills from one end of the hill tracts to the other; and this distribution is so marked that this class of

forest hardly ever appears beyond the first water-shed running from the north to the south. The chief tree here is the wood-oil tree, which grows to an immense size. The oil is obtained by incisions made in the trunk two or three feet from the ground; and these trees are charred periodically by fire, so as to induce the oil to flow more freely. Besides the oil, the timber is very valuable for planking and boat-building (*Gardeners' Chron.*, August 25, 1877).

Cyperus Esculentus.

Some members of the Central Horticultural Society of France are engaged on some cultural and applicatory experiments with *Cyperus esculentus* — a sedge having edible, tuberous roots. Some cakes, and a preparation of a kind of orgeat from the tubers, were declared by the society to be excellent; and further experiments were recommended. It had been objected that the cultivation of this plant in the climate of Paris would often prove unprofitable, because it is very susceptible to frosts, and the tubers are destroyed by comparatively slight frosts; but by the method of cultivation found most successful this is of little consequence, as the sowing or planting is done in May, and the season for lifting and using the tubers commences in August and terminates in October. The following analysis of the composition of the tubers is interesting, though it does not appear probable that the products of this plant will ever be of sufficient quantity to become of real commercial importance: In 100 parts there are 7.10 of water, 28.06 of oil, 29 of starch, 14.07 of crystallizable sugar, 0.87 of albumen, 14.01 of cellulose, and 6.89 of gum, coloring matter, and salts.

The Prickly Pear.

The Mexicans prepare a cooling drink called *colindre* from this plant; and the French, in various parts of America, make very pretty ornamental vases and flower-trays out of the net-work found in its stems. I have often eaten the fruit in America; and an American gentleman, a good botanist, told me that he had seen the plant growing in lava at the foot of Mount Etna when he visited Europe. The Indians of Florida used to live upon its fruit for three months in the year, and settlers in California think it is invaluable as

a fence. They plant three rows of it close together, and defy any mortal animal to break through (H. E. Watney in *Gardeners' Chron.*).

Poisonous Grasses.

In the September number of Trimen's *Journal of Botany* there is an interesting note by Dr. Hance on Intoxicating Grasses, which supplements a previous article on the same subject. A grass was sent by Dr. Aitchison from Cashmere, which Professor Dyer determines as *Stipa Sibirica*, Munro. Concerning this grass Dr. Aitchison writes (date of August 4, 1875): "I have just been collecting some good specimens of a grass that is extremely common near Gulmuz. It grows in large tussocks, and is very poisonous to horses and cattle. The cattle are too knowing, and will not eat it. Horses from the plains do eat it, and die from its effects; but if quickly treated, recover. They become comatose and lose the power of their limbs. It grows in the Scinde valley also. While there I heard of it and the cure—viz., smoking them, by making a large fire and keeping the horse's head in the smoke. The nose commences to run first; and if it does so freely, the beast is safe. The natives also say that if a cow eats it they give acid, unripe apricots, or any vinegar, which aids the recovery. A large number of the horses this year at Gulmuz were poisoned by it; none died, as all smoked their horses." In Dr. Hance's previous article mention was made of a statement by a French missionary which is materially identical with the above. Professor Dyer suggests in a note to Dr. Hance that the Stipas may be only mechanically poisonous, like *Hordeum pratense;* but Dr. Hance adds that though it is indisputable that various grasses in Europe and Australia cause injury or death to cattle from their irritant properties, the special symptoms in the case of the *Stipa* and in *Melica* seem opposed to such a supposition. "In a recently published translation of Przewalski's 'Travels' the Alaskan poisonous grass is said to be a species of *Lolium;* and it is added that the native herds carefully avoid eating it" (*Naturalist*, November, 1877).

History and Uses of Jaborandi.

The *Bulletin* of the French Society for Acclimatization for October contains a long account of the history and uses of

the true jaborandi, *Pilocarpus pinnatus*. It appears that its introduction, or rather reintroduction, is due to a Brazilian (Dr. Continho), who brought some leaves of it for his personal use about two years ago. He attended Professor Gubler's lectures; and, when speaking of sudorifics, the learned professor of the faculty of medicine observed that no drug in use really deserved the name. This statement induced Dr. Continho to bring the jaborandi into notice. The report in the publication referred to is a lengthy one, giving the results of the most important experiments made with this drug by eminent physicians. The physiological action of infusions, chemical composition, and the physiological action of the peculiar alkaloid pilocarpine are detailed. *P. simplex* gave similar results. It is not only a powerful sudorific, but an equally active sialogue.

Vegetable "Eider-Down."

In the *British Journal of Botany* for July, 1877, is the following extract from a letter of the Rev. James Graves, Secretary to the Royal Irish Archæological Association, to Professor Babington: "Mrs. Graves bought a so-called eider-down quilt the other day. On opening it, the down was found to be as the sample enclosed. Is not this the down of the cotton-rush, so conspicuous in our bogs?" In answer Professor Babington says: "It is certainly the down of *Eriophorum;* but I have not determined which species — nor does it much matter, since any would do as well, or rather ill, in place of eider-down." In this connection may be mentioned a substance found in the head-dress of a Sandwich-Islander, now in the museum of the Peabody Academy of Salem, which resembled a filiform sponge, and was sent to Professor A. Hyatt for determination. It proved to be merely the pith of some species of *Juncus*, a curious ornament for a head-dress.

Charcoal for Gunpowder.

The large consumption of dog-wood for this purpose of late years in Europe has produced a scarcity of this material. The Royal Gunpowder Factory at Waltham Abbey appears to have drawn its supplies of *Rhamnus frangula* wood from Germany, though it might be grown in England on the coppice system with the greatest ease. A substitute has, how-

ever, been proposed, and a specimen of the wood was sent to Kew for identification. It was determined to be hornbeam (*Carpinus betulus*), which has been, at any rate formerly, employed for gunpowder manufacture at Berne (*Rep.* Kew Gardens).

Homogone and Heterogone or Homogonous and Heterogonous Flowers.

That difference in relative length or height of stamens and style, reciprocally, which in Torrey and Gray's "Flora of North America" was very long ago designated by the term *diœco-dimorphism*, Mr. Darwin (who detected and has made much of the meaning of the arrangement) called simply *dimorphism*. Besides these *dimorphic*, he also brought to view *trimorphic* flowers. The first name is too long for use, and carries with it some ambiguity, since it may imply a separation as well as a diversification of the sexes. Mr. Darwin's term has the disadvantage of not indicating what parts of the blossom are *dimorphic* (hermaphrodite flowers may be dimorphous in the perigonium); and a more generic name is now required on account of trimorphic, etc. This has been supplied by Hildebrandt in Germany, who has introduced the term *heterostyled* and the counterpart *homostyled*. These are not particularly happy appellations; for the difference is in the stamens as well as in the pistil, and in the latter is not always restricted to the style. Well-established terms ought not to be superseded on the ground of improvement; but those which have not yet taken root sometimes may be. Following the analogy of *perigonium* or *perigone*, I propose the more exactly expressive term of *heterogone* (or *heterogonous*) for these flowers, such as those of *Primula*, *Houstonia*, *Lythrum*, etc. The counterpart *homogone* (or *homogonous*) would designate the absence of this kind of differentiation. These terms, either in Latin or English form, would work well in generic or specific characters, and have the advantage of etymological correctness (Asa Gray in *American Naturalist*).

Three Feet of Fern-Spores.

Bureau and Poisson have examined a substance found in large quantities in a cave at Reunion Island. The cave is ten meters in depth by six meters square, and is covered to

a depth of more than a meter by a yellow, soft, insipid, inodorous substance, which crumbles under the fingers to an impalpable powder. The dry powder burns without flame or odor, but when moistened gives off during combustion much smoke and odor of a burning plant. By exclusion they have decided that this matter consists of the spores of species of ferns, probably *Polypodiaceæ*. The spores are not those of *Lycopodiaceæ*, according to the writers; but they have the shape, markings, and *color* of the spores of the *Polypodiaceæ*, with large fronds now occurring on the island (*Naturalist*, May, 1877).

Vegetable Poisons of Samoa.

The vegetable poisons used by the Samoa-Islanders to coat their spears and arrows formed the subject of a paper by the Rev. Thomas Powell, read at the Linnæan Society, March 15. It is stated that human thigh-bones are used to tip the weapons. These latter are dipped into a composite material the chief poisonous ingredient of which is a milky juice from several trees, among others *Calophyllum inophyllum*. To this is added a substance got from wasps' nests, and also the fluid derived from putrescent sea-cucumbers (*Holothuria*). After dipping, the arrows are smoked in a kind of kiln, and stuck into the flower-stalk of a species of *Tacca*. Thus preserved from damp, they are laid aside ready for use as occasion may arise. The poison, it is said, brings on convulsions and tetanus, and death follows; though occasionally only irritating wounds arise. Berthold Seemann, in his "Flora Vitiensis," has already described certain trees said to yield poisonous extracts, and these somewhat agree with this later account. There are others, however, that are dubious as to the virulent effects that may arise from the said poisoned weapons (*Gardeners' Chron.*, March, 24, 1877).

Sarracenia Variolaris.

In 1874 I prepared notes on *S. variolaris*, in which it was stated, as one of the conclusions reached, that the sweet secretion at the mouth of the tubes was simply a lure to insects, and not stupefying or intoxicating, as had been supposed. Last year, having read an interesting article on this subject, in which the writer arrived at conclusions directly

opposed to my own, I was curious to discover whether I had committed any error; but it was too late at that season to repeat former experiments.

On the 15th of this month, therefore, I procured, about midday, from a neighboring pine barren a number of leaves of this plant which were brilliantly colored and secreting freely. While still fresh, the upper portions of these leaves were cut off and slit open, thereby exposing the honeyed secretion on the internal surface, which was very abundant and glistening, sweet to the taste and viscid to the touch. These were then flattened out on a large newspaper, the whole surface of which was covered with them. Many house-flies were soon attracted and commenced to feed, and I carefully watched their motions without any interruption for the space of one hour. The result was precisely as previously stated. In no instance did I discover the slightest unsteadiness or tottering in any of the flies, although I watched some of them feeding at one spot for at least ten minutes, at the expiration of which time they flew off, apparently unhurt. They continued feeding and flying off from the leaves during the hour I watched them, and certainly not one fell, nor was there any indication at any time of either stupor or intoxication.

These experiments I repeated in the same way on the 25th (but later in the day), and as carefully as on the previous occasion, and with precisely the same results; also on the next morning (26th) with plants which had been collected the day before, and these seemed to secrete still more freely. I ask, therefore, if flies and other insects are indeed intoxicated from eating the honey when they are *within* the tube, why should not the same intoxication result when the tubes are opened and flattened out? I conclude, then (as I did before), that it is only the peculiar conformation of the leaf in its overhanging hood and internal slippery surface which entraps and finally destroys insects, and that the sweet exudation is only a lure, and not intoxicating in any way. I may remark that after flies and other insects slip and stumble, if they were indeed intoxicated or stupefied, it seems likely that they would remain at the lower portion of the leaf, and that their motions would be feeble and sluggish. On the contrary, their efforts for escape are most active and vigorous,

the flies flying and buzzing continually, and other insects incessantly climbing and falling back. It is only after being exhausted by their efforts that they eventually get slimed by the liquid at the base of the leaf, and stupor then overtakes them.

I have seen ants, and occasionally flies also, fall immediately as they entered the leaves before they could have eaten honey.

I remark, further, that if this sweet internal secretion be stupefying, that outside on the wing (the "trail") must be equally so, and therefore insects ought to be found at the base of the leaves on the ground. I have never myself seen such, nor have I ever heard of any other persons observing dead or intoxicated insects outside (J. H. Mellichamp, Bluffton, S. C., in *American Naturalist*).

Fertilization of Gentiana Andrewsii.

Humble-bees are in the habit of entering bodily into the flower of this gentian, forcing open the mouth of the corolla to do so where this is closed (as it is in the absence of sunshine), and the anthers open before the stigmas separate to expose the pollen-receiving surface; so it is evident that cross-fertilization is provided for. Our correspondent, Mr. M. W. Vandenberg, of Fort Edward, N. Y., communicates the result of some observations which show that this flower has likewise an arrangement for self-fertilization. The short tube of cohering and extrorsely opening anthers is higher than the stigma when the blossom first opens. The pistil afterwards lengthens, so that its apex protrudes; the broad and introrse stigmas now separate, at first moderately, but at length they diverge strongly and become revolute, so as to bring a portion of the broad stigmatic surface into contact with the outer face of the anther tube, which usually is still covered with abundance of pollen. The pollen appears to retain its freshness for a long time, and in this slow movement of revolution of the stigmas they are seen to take up considerable masses of the moist pollen. Those stigmas, therefore, which have failed to receive extraneous pollen from bees during the first day or two of anthesis will afterwards secure it from their own anthers. "Get fertilized—cross-fertilized if you can, self-fertilized if you must—is nature's golden rule for flowers" (A. Gray, in *American Naturalist*).

AGRICULTURE AND RURAL ECONOMY.

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The year 1877 has been remarkable for the manifestations of increased interest in the study and the practical applications of agricultural science. A report of progress in this direction will most properly begin with the agricultural experiment stations, from which by far the largest part of the investigations come.

AGRICULTURAL EXPERIMENT STATIONS.

Growth of the Experiment Stations.

The twenty-fifth anniversary of the founding of the first European station was held at the parent institution in Moeckern September 15, 1877. The reports and statistics prepared for this meeting furnish a proof as cheering as it is convincing that agriculture is gradually coming into line with the other arts and industries in the march of modern progress, and making use of its share of the benefits of science.

The first agricultural experiment station was established in 1852, by some progressive farmers, at Moeckern, near Leipsic, in Saxony. There are to-day no less than 119 regularly organized agricultural experiment stations in the different countries of Europe—Portugal, Greece, and Turkey being the only ones without them.

The rate of progress of the experiment-station idea will appear from the following figures, which show the number founded each year since 1852:

1852......	1	1859......	2	1866......	4	1872......	12
1853......	1	1861......	4	1867......	1	1873......	6
1855......	1	1862......	1	1868......	2	1874......	8
1856......	3	1863......	3	1869......	5	1875......	14
1857......	6	1864......	6	1870......	7	1876......	7
1858......	1	1865......	4	1871......	7	1877......	20

The number thus given is 127. To these should be added

6, the exact dates of whose founding it is not easy to find, making 133 in all. Of these, 14 have been discontinued or replaced by others, leaving 119 in actual operation.

These stations are distributed among the countries of Europe as follows:

Prussia	29	Austro-Hungary	13
Bavaria	12	Italy	16
Saxony	6	Sweden	7
Baden	3	Russia	3
Würtemberg	2	Belgium	5
Brunswick	2	Switzerland	3
Other German states	12	Other European countries	8
Total in Germany	66	Total in Europe	119

Besides these 119 regularly organized stations, there are not far from 50 laboratories and other institutions, mostly connected with universities and agricultural schools, and devoted to agricultural researches. There are, for instance, some 20 such establishments in France, as many more in Germany, a number in Russia, and so on.

Resources, Appliances, and Work of the Experiment Stations.

The work of the stations is varied. Each one has usually a specialty, though in many, indeed, the majority of cases, one will follow several lines of investigation. Of the branches of mere purely scientific experimenting, 16 European stations are engaged in investigations of soils, 24 in experiments on culture and manuring, 13 in grape-growing and wine-making, 3 in orchard-culture, 1 in olive-culture, 9 in forestry, and 2 in reclaiming marshes and moors. Researches upon vegetable physiology are carried on in 28; upon diseases of plants in 11; upon animal physiology, feeding of domestic animals, etc., in 20; upon questions connected with dairying in 11; silk production in 6; agricultural technology in 4; sugar industry in 3; manufacture of alcoholic liquors in 4; and chemical technology in 22. Among the exclusively practical forms of work 54 exercise a control over the sale of fertilizers, 38 over the sale of feeding-materials, and 44 over the sale of seeds.

For appliances each station has, first of all, a chemical laboratory. In addition, a few have farms, experimental fields, or gardens. More have stables for cattle, or greenhouses for

plants, under experiment. Most of the larger and more successful ones are connected with universities or agricultural schools, whose advantages are found of much more practical utility than those of isolated farms.

The working force of each station consists of a director, who is very often professor in a university or school, and usually one to three or four skilled chemists as assistants, besides sometimes a farm superintendent and servants.

The support of the stations comes from government appropriations, from contributions from agricultural societies, corporations, schools, and individuals, and from analyses of fertilizers, feeding-materials, etc. The revenues of the German stations average some $2375 per annum, of which about 52 per cent. comes from governments, 17 per cent. from agricultural societies, corporations, and private individuals, and the rest from analyses. The largest government appropriation to any one station is $3750. The largest total revenue is $7900; the smallest, $600.

A report prepared for the anniversary at Moeckern, above mentioned, and giving statistics of the stations during the first twenty-five years of their existence, forms an octavo volume of 449 pages. A bare outline of the organization, equipment, and kind of work of each station occupies 140 pages. No less than 152 pages are filled with the mere titles of their investigations.

In short, there are to-day in Europe over 170 institutions, in which not less than 250 chemists and physiologists are devoting their labor to scientific researches for the benefit of farming. Such is the picture of the present status of agricultural investigation in Europe.

Experiment stations in the United States are still in their infancy, but promise a brilliant future. Only two have as yet been successfully inaugurated — one in Connecticut and one in North Carolina. Efforts are in progress, however, to secure the establishment of stations in a number of other states. Several of our leading universities, agricultural schools, and bureaus and boards of agriculture have been doing excellent work in this direction, notably the Bussey Institution of Harvard University, the Georgia Bureau of Agriculture, and various others.

THE ATMOSPHERE AS RELATED TO VEGETATION.

Nitrogen Compounds Brought to Soil by Snow.

Messrs. Ballart and Comstock report some determinations of the amounts of nitrogen compounds in snow, conducted under the direction of Professor Perkins, of Union College. Three samples of fresh snow gave, on the average, in 100,000 parts by weight, 0.0465 part of ammonia, and 0.041 part of organic nitrogen. From these figures the total amount of ammonia and of organic nitrogen to the acre for each inch of water (that is, melted snow) is found to be—ammonia, 0.1055 pound; organic nitrogen, 0.093 pound.

Using as a basis the observations at the Dudley Observatory, according to which the total snowfall last winter (November 1, 1876, to March 31, 1877) was five feet eight inches, and reckoning ten inches of snow equal to one inch of water, the authors calculate that in this winter's snowfall "there could not have been more than 0.69419 pound of ammonia and 0.61194 pound of organic nitrogen to the acre. This shows that though snow may be a great protective to the ground, still it does not act as a very powerful or rich manure.

Influence of Forests upon Rainfall and Temperature.

Fautrat has continued his observations upon the temperature, the hygroscopic condition of the atmosphere, and the rainfall over forests, as compared with those over adjoining open territory, noting at the same time the amounts of water in the soils. He had previously found more moisture and more rainfall over a forest of deciduous trees than over open land. The amount of water received by the forest soil was less, however, because the trees kept part of the rain from reaching it. But, on the other hand, the tree-covering so diminished the evaporation from the forest soil that the latter retained much more water than did the open land. Similar observations have since been made upon forests of evergreen trees and adjoining open land. The results are similar in kind to those with deciduous trees, but more marked. The rainfall over a pine forest was, on the average, 10 per cent., and that over a forest of oak and beech 5 per cent. more than over adjoining open fields. The total rainfall

over the pine forest during fourteen months was 33.1 inches; that over a sandy plain, at a distance of 1.9 miles, only 29.9. Of that which fell on the forest only 18.6 inches reached the ground. But through the influence of the trees, moss, and fallen leaves, the evaporation was so decreased that the forest soil retained a good deal more of the rainfall than the open lands. Among the important general inferences from these observations are that forests (1) tend to equalize extremes of temperature; (2) act as condensers of atmospheric moisture, and hence (3) increase deposition of dew on neighboring lands and (4) attract more rainfall; (5) prevent part of this from reaching the soil; (6) enable the soil to retain much better what it does get, so that it has more for future supply of springs and streams than the open land, (7) and thus tend to prevent both floods and drouth. These conclusions apply with especial force to evergreen forests. The economy of nature in covering sandy and calcareous regions with forests of pine thus becomes clearly apparent.

THE SOIL IN ITS RELATIONS TO VEGETABLE PRODUCTION.

Agricultural Geology.

The science of agricultural geology, or, as some of its followers prefer to term it, geognosy, has received a new impetus in the researches and publications of Professor Orth, of the Agricultural Institute of the University of Berlin. Besides his valuable prize essay ("Die Geognostisch-Agronomische Kartirung") Professor Orth has lately published a series of six charts, each giving six diagrams in profile of the characteristic sedimentary soils of North Germany. They show the different strata of surface- and sub-soil, their thickness and other characters, down to a depth of three meters—about ten feet. These, with the investigations upon which they are based, illustrate most forcibly how incomplete a measure of the value of a soil can be furnished by chemical analysis alone, and how extended studies and observations are necessary to a full knowledge of the factors that decide its fertility.

New Jersey Marls.

The annual report of the New Jersey Board of Agriculture for 1876 devotes some eighty-four pages to a descrip-

tion of the geological characteristics, chemical composition, and agricultural uses of the marls of that state. The general conclusions as to the agricultural value of the greensand marls which are the most important are, in substance, that (1) those containing the largest percentage of phosphoric acid are the most valuable; (2) those rich in carbonate of lime are the most durable; (3) the potash in them has but very little, if any, present value, it being combined with silica, and hence insoluble; (4) the greensands, containing but little of either phosphoric acid or carbonate of lime, become active fertilizers when composted with quicklime; (5) the injurious effect of sulphate of iron in the marls can be counteracted by composting with lime; (6) the crops particularly improved by them are all forage crops (grass, clover, etc.), potatoes, buckwheat, wheat, rye, oats, and corn. The Tertiary and calcareous marls seem to be very useful, but less so than the greensand.

Percolation of Water through the Soil, and Consequent Loss of Plant-Food.

The *Scientific Farmer* reports some very interesting and instructive experiments by Dr. Sturtevant on the relation between the amount of water which falls in rain and that which percolates through the soil. These are made by means of a lysimeter with an area of one five-thousandth of an acre, on the plan of those performed at Rothamstead, in England, and other places in Europe. The soil was a gravelly loam. The total rainfall during the year 1876 was 43.88 inches, of which only 4.76 inches leached through to a depth of twenty-five inches. That is to say, only 11 per cent. of the total amount of water which fell percolated to this depth; while in European experiments (under varying conditions of soil-depths at which tests were made, etc.) the percentage of percolation varied from 20 to 42.5 per cent. Dr. Sturtevant infers that the waste of fertilizing elements from New England soils by drainage must be much less than in England.

Loss of Plant-Food through Rivers.

Breitenlohner and Harlacher calculate that the river Elbe, which takes up all the Bohemian rivers, and carries off five milliards of cubic meters of water per annum, takes with this

455,950 tons of suspended matters and 518,900 tons of dissolved matters—making, in all, 974,850 tons. This includes some 117,000 tons of lime, 23,440 tons of magnesia, 45,430 tons of potash, 33,000 tons of soda, 21,100 tons of chloride of sodium, 38,080 tons of sulphuric acid, and 1250 tons of phosphoric acid (*Dingl. Polyt. Journal*, ccxxiii., 328).

Soil-Absorption.

One of the most important factors of the fertility of soils is their faculty of absorbing the ingredients of plant-food from their solutions, and retaining them for the use of plants. In a new work by Detmer on soils ("Die Naturwissenschaftlichen Grundlagen der Bodenkunde"), 60 pages, and in Thiel's "Landwirthschaftliches Conversations-Lexikon" (Agricultural Encyclopædia) now being issued, 12 pages, are devoted to the discussion of this subject. Detmer gives conclusions essentially as follows:

1. Ammonia, potash, lime, magnesia, sulphuric acid, silica, and phosphoric acid may be absorbed by soils. Nitric acid and chlorine are not absorbed to notable extent.

2. When these substances are supplied in the free state to a soil, they enter into combination with its ingredients. When a base is absorbed by the soil, from a salt in solution, an equivalent amount of another base leaves the soil, and goes into the solution.

3. The soil absorbs a given ingredient of a salt most energetically when the other ingredients of the salt are at the same time recombined.

4. From very dilute solutions nothing is absorbed.

5. The time of contact between soil and solution does not essentially affect the amount of absorption.

6. The absorption is increased by heat, and is peculiarly affected by the amount of soil and the amount and concentration of the solution. Nos. 4 and 6 refer more especially to the observations made in laboratory experiments.

Heiden, the author of the article on Absorption in the Encyclopædia referred to, who has himself made a good many experiments upon the subject, arrives at conclusions not widely different from those of Detmer. He shows, however, that the absorption of sulphuric acid is very slight.

As to the question in how far the elements that have been absorbed by the soil may be redissolved and carried away again, Heiden states—

(1) As to bases. The bases do not become entirely insoluble by absorption, but the amount of water required to redissolve them is far greater than that in which they were originally dissolved. The force with which the soil holds the absorbed base is far greater than that which the water can exert to remove it.

(2) As to acids. Phosphoric and silicic acids are, like the bases, redissolved to slight extent, but require for this purpose very large quantities of water. Sulphuric acid is absorbed but little; nitric acid and chlorine scarcely at all; and all three, but especially the two latter, are very easily removed from soils by water.

The Causes of Soil-Absorption

Have been much discussed and experimented upon. The main questions in dispute are as to how far they are physical, dependent upon surface attraction; how far they are chemical, due to chemical combination; and what ingredients of the soil and what special circumstances decide the absorption. The absorption of phosphoric acid seems to be a chemical process dependent upon its combination with lime and magnesia, and more especially with iron and alumina. The absorption of silica seems likewise to be due to chemical combination, particularly with lime and alumina, to be decreased by humus, and hence greatest in soils containing little organic matter.

The Absorption of Bases by the Soil

Has been lately studied by H. P. Armsby, with a view to gain light upon the question as to how far this is due to chemical and how far to physical causes. The view that the prime cause of the absorption is a physical one—surface attraction—has been held by several experimenters, as Liebig, Henneberg and Stohmann, Peters, and Brustlein; while the investigations of Way, Eichhorn, Rautenberg, Heiden, Knop, Warrington, and Pilitz show clearly that chemical changes are involved. The prevailing opinion has been that these chemical changes consist mainly in the exchange of

bases of hydrous silicates in the soil for the base absorbed from the solution, though several have considered that the oxides of iron and alumina, and some organic compounds, play a very important rôle. Armsby concludes from two series of experiments, one with soils and the other with hydrous silicates, that "the absorption of combined bases by the soil consists in an exchange of bases between the salt and the hydrous silicates of the soil; and that this exchange, which is primarily chemical, is only partial, its extent varying—1st, with the concentration of the solution; 2d, with the ratio between the volume of the solution and the quantity of the soil used."

"The cause of these variations is probably the 'action of mass,' or the tendency of the resulting compounds to re-form the original bodies, the absorption actually found in any case marking the point where the two forces are in equilibrium" (*Am. Jour. Sci.*, XIV, 1877, p. 25).

On the whole, the results of later investigation seem to lead towards the conclusion that the cause of the absorption of acids is mainly, if not entirely, chemical; that of bases, partly physical but chiefly chemical.

Oxidation of Nitrogen Compounds in the Soil.

To test the action of organized ferments upon the oxidation of nitrogenous compounds, Schloessing and Müntz filled a wide glass tube, a meter in length, with ignited sand mixed with 100 grams of powdered chalk. The mixture in the tube was watered every day with a fixed quantity of sewage. After twenty days nitric acid appeared in the water flowing from the bottom of the tube, and increased rapidly until the last trace of ammonia disappeared. After four months chloroform was passed through the tube to kill the ferments. The formation of nitric acid ceased at once, and did not begin again until fresh germs, obtained from land possessed of marked nitrifying properties, were sown in the sand. It is thus shown that nitrification may be caused by organized ferments; and that a sandy and barren soil, if it contain enough lime to neutralize the nitric acid, may serve admirably for the purification of sewage.

SOURCES AND FUNCTIONS OF INGREDIENTS OF PLANT-FOOD.

The Sources of the Nitrogen of Vegetation.

An address "On Some Points in Connection with Vegetation," delivered at South Kensington by Dr. J. H. Gilbert, has been reprinted in the *American Journal of Science* (vol. xiii., pp. 20–32, 99–111, 181–195). This treats of the subject of the nitrogen of vegetation in general, and of agricultural production in particular, especially as viewed in the light of the results of the well-known experiments at Rothamstead, England, in which Dr. Gilbert has, in connection with Mr. J. B. Lawes, been engaged for some thirty-three years or more. As a summarizing of those results, by themselves and in comparison with those of other experimenters, it forms a most valuable contribution to our still extremely incomplete knowledge of the ways of supply of nitrogen to crops, and will form a convenient basis for our *résumé* of this topic.

Sources of Nitrogen Removed from the Soil by Crops without Nitrogenous Manure.

Crops grown on soils to which no nitrogen is applied in manure remove considerable nitrogen. This nitrogen may be accounted for by (1) the combined nitrogen coming down in rain, snow, etc., which does not exceed eight or ten pounds per acre yearly where observations have been made; (2) the condensation of ammonia of the air within the pores of the soil; and (3) previous accumulations within the soil.

Whether the excess of nitrogen taken by the plant over and above what is brought to the soil by atmospheric precipitation, condensation of ammonia by the soil, etc., comes entirely from the previous stores in the soil; or whether, and in how far, it is otherwise supplied—*i. e.*, through assimilation of atmospheric nitrogen by plants and soils—is a much-vexed question, on which the summarizing of the results of Messrs. Lawes and Gilbert's experiments throws a good deal of light. Certain it is that as crops are removed year after year their amounts decrease, and that at the same time the store of nitrogen in the soil diminishes wherever accurate tests have been made. In the Rothamstead ex-

periments it is noticeable that the "root crops"—turnips and sugar-beets—fell away more in their yield, and exhausted the nitrogen of at least the superficial layers of the soil, more than the gramineous crops wheat and barley, and, indeed, more than any other crop.

Leguminous Crops and Soil Nitrogen.

Referring to the fact that leguminous crops contain much more nitrogen than gramineous crops, Dr. Gilbert says that "we have no evidence leading to the conclusion that this increased assimilation [of nitrogen] is done at the expense of the nitrogen of the soil." On the other hand, after taking away so much more nitrogen than other crops, they leave a good deal more behind. In discussing the well-known fact that leguminous crops receive less benefit than others from nitrogenous manures, he cites the results of a number of comparative soil-analyses after clover and after barley. These "all concurred in showing an appreciably higher percentage of nitrogen, especially in the surface soil (nine inches deep) of the land from which the clover had been removed than that from which the barley had been taken; and this was so, although in every case all visible vegetable débris had been carefully picked out. Here, then, the surface soil, at any rate, was positively enriched in nitrogen by the removal of a very highly nitrogenous crop."

Assimilation of Nitrogen by Leguminous Crops Aided by Potassic Fertilizers.

In experiments on the mixed herbage of grass land continuing through twenty years, "complex mineral manure" without potash increased the yield over unmanured plots 41 per cent.; the same with potash increased it 67 per cent. The extra increase with potash was due almost entirely to leguminous plants which the potash brought in. The average annual yield of nitrogen per acre without potash was 38.1 pounds, with potash 56 pounds. Dr. Gilbert concludes that "mineral manures, and especially potassic manures, increase in a striking degree the growth of crops of the leguminous family grown separately, and coincidently the amount of nitrogen they assimilate over a given area."

We may add that this observation, which is well substan-

tiated by the Rothamstead experiments, is quite in accordance with the fact that, as considerable experience has shown, the German potash salts are particularly useful for clover, beans, vetches, and other leguminous crops.

Is the Free Nitrogen of the Air a Source of the Nitrogen Assimilated by Plants?

The theory that plants can directly assimilate the free nitrogen of the air was long since disposed of by the experiments of Lawes and Gilbert, and of Boussingault. It has still been maintained that free nitrogen could be oxidized by the aid of ozone, and the resulting compounds directly absorbed by plants. Six methods for this oxidation of nitrogen have been alleged: (1) by ozone assumed to be evolved by plants; (2) by contact of nitrogen with bodies undergoing oxidation; (3) during electrical discharges in the air; (4) the combining of ozone with nitrogen in the presence of water; (5) the same in presence of bases, as alkalies, lime, baryta, etc.; and (6) through evaporation and condensation of water in presence of air. Ville supposes that ozone is evolved by plants and combines with nitrogen in solution in their juices. It has been quite generally assumed that nitrogen outside the plant tissues could be oxidized by ozone exhaled by the plant and then absorbed by the leaves. From experiments at Rothamstead, as well as from those of Boussingault, Dr. Gilbert strongly doubts both the above assumptions, and adds that "whether such actions take place or not, it is at any rate certain that in our own experiments we have not been able to persuade plants to avail themselves of this happy faculty of producing their own nitrogenous food."

E. M. Dixon, in a "Report to the Philosophical Society of Glasgow on the Production of Nitric Acid from the Free Nitrogen of the Air," doubts whether the nitrogen is oxidized by ozone in presence of bodies undergoing oxidation—method (2) above—and as good as denies nitrification by ozone in presence of water (4). Concerning the theory of the formation of nitrite of ammonia (6) claimed by Schönbein to be established by his experiments, and to explain the absorption of nitrogen by vegetation, he remarks, "It is, however, unfortunate . . . [for this theory] that no sooner

did experimentalists begin to purify the air that they used in repeating Schönbein's experiments than the production of nitrite of ammonia suddenly stopped."

Concerning the combination of ozone with free nitrogen in presence of bases, (5), in experiments by Berthelot, ozone prepared from oxygen by the electric discharge did not oxidize nitrogen in presence of chemically pure baryta water; but air ozonized by phosphorus yielded a trace of nitrate. If the phosphorus was free from nitrogen, the oxidation of free nitrogen by ozone in presence of bases would thus seem to be established (*Comptes Rendus*, lxxxiv., 61).

Is the Combined Nitrogen of the Air the Source of the Assimilated Nitrogen?

It so happens that plants which gather, or are supposed to gather, nitrogen most readily, as root crops (turnips and the like) and leguminous crops (beans, pease, clover, etc.), have obviously a different foliage from the gramineous crops (wheat, barley, oats, etc.), which are supposed to gather it less easily. It has been commonly taught that the "broad-leaved crops," as the former are designated, have a power of taking nitrogen from the atmosphere in some manner which other crops possess in less degree, if at all. Dr. Gilbert opposes this view very decidedly: "It may be safely asserted that neither direct experimental evidence nor a consideration of the physics of the subject would lead to the conclusion that the plants which assimilate more nitrogen over a given area than others do so by virtue of a greater power of absorbing from the atmosphere by their leaves combined nitrogen in the form of ammonia." It is worthy of notice that A. Mayer, whose experiments are cited in support of the theory referred to, says himself that "this hypothesis rests more upon practical experience than upon exact experimental testimony," and accepts it to only a very limited degree.

The supposed means by which plants might prepare for themselves, or get already prepared, and absorb through their leaves compounds formed from the free nitrogen of the air, would thus seem probably limited to one.

Nitrification by Electrical Discharges.

The oxidation of free nitrogen by electrical discharges has long since been established. Whether enough of the nitrogen of the air is thus oxidized and then absorbed by plants to be of much consequence is very doubtful. But late researches by Berthelot have revealed a very noteworthy manner in which nitrogen may be absorbed by organic compounds, under the influence of the silent electrical discharge. A large number of compounds were thus found to absorb nitrogen, both that existing in the pure state and that in the air, producing compounds all of which evolved ammonia on being heated, either alone or with soda-lime. Berthelot suggests that similar processes may take place in nature, and that consequently plants may be able to assimilate nitrogen directly from the air. This last assumption is, however, opposed to the results of the best previous investigation upon the subject, which indicate that the free nitrogen of the air is not assimilated by plants (*Comptes Rendus*, lxxxii., 1283, and lxxxiii., 677).

Is the Nitrogen Combined under the Influence of the Soil a Source of the Supply Assimilated by Plants?

Does not the soil gather free nitrogen from the air and induce it, in some way or other, to enter into combinations in which it can be used by the plant? This is a question which, though not yet decided, seems, in the light of recent experimenting, to approach an affirmative answer. In the *résumé* in the *Record* for 1876, in discussing the probability of the direct assimilation of atmospheric nitrogen by plants, the remark was made that "it would seem more probable that the absorption of free nitrogen by humus and by soils containing humus, which Simon and Truchot claim to have observed, might be induced in the manner described by Berthelot." The experiments of the past year bring no new evidence of importance against this view. On the other hand, it seems more and more probable that the ways in which crops get their supplies of nitrogen are to be sought in the varying capacities of their roots for feeding upon the nitrogen contained in various forms in the soil. Dr. Gilbert concludes the remarkable address to which we have been referring

with the words: "And now, to summarize in a few words the results of this whole discussion, I think the balance of the evidence points to the conclusion that the answer to the question, What are the sources of the nitrogen of vegetation in general, and of agricultural productions in particular? is more likely to be found in the relations of the atmosphere and of the plant to the soil than in those of the atmosphere to the plant itself."

On the whole, the evidence is decidedly against the theory so stoutly maintained by some, particularly Ville, that plants obtain considerable, some a large share, of their nitrogen by their leaves from the air.

Best Forms of Nitrogen for Plant-Food.

The important question as to the form of nitrogen most suitable for the nutrition of plants has been studied by Lehmann, who has lately experimented with buckwheat, maize, and tobacco, supplying nitrogen in some cases in the form of nitrates, and in others in the form of ammonia salts. He concludes that some plants require ammonia in their first period of vegetation, and nitric acid in the second, but that ammonia may, by oxidation in the soil, produce the nitric acid needed.

Hässelbarth has studied the assimilation of nitrogen by barley. The whole of the nitrogen was absorbed, and the total yield of dry substance the same, when the nitrogen was supplied as calcium nitrate or as ammonium nitrate in soil free from marl. In marled soil the nitrogen was wholly absorbed when supplied as ammonium sulphate or chloride. When the latter salts were applied to unmarled soils, only one half of the total nitrogen was absorbed. The worst results were obtained by using acid ammonium phosphate: in marled soil only three fifths and in unmarled soil only one seventh of the nitrogen was absorbed, the yield being correspondingly small. It appears from these experiments as though barley could absorb the nitrogen only when present as a nitrate, or under conditions that permit of ready transformation to a nitrate (*Chem. Centralblatt*, 1876, 821).

It is worthy of note here that in the experiments of Lawes and Gilbert on grass land, nitrogen in the form of nitrate of soda, which finds its way into the deeper layers of the soil

more readily than in the form of ammonia salts, favored the growth of deep-rooted plants. Hence the herbage on plots manured with nitrate of soda stood the drought much better than that manured with ammonia salts.

Source of the Carbon of Plants.

The question as to the source of the carbonic acid from which the carbon of plants is obtained, whether it is derived exclusively from the atmosphere or partially from the soil, has been long discussed. Liebig was of the opinion that a portion was obtained from the soil through the roots, while Boussingault believed that the larger part, if not the whole, comes from the air through the leaves. Experimental data for the decision of the question have, however, been lacking. Boehm, from experiments with the scarlet-runner bean, concludes that young plants do not take up from the soil either organic compounds or carbonic acid. He considers it not improbable that the carbon of the carbonic acid decomposed by plants unites directly with water to form starch (*Ber. d. D. Chem. Ges.*, ix., 123).

We have lately accounts of some very ingenious and interesting experiments by Moll, from which the author derives, evidently with good ground, several conclusions, of which the resultant is that plants derive none of their carbon from the carbonic acid imbibed from the soil through the roots (*Landw. Jahrb.*, 1877, vi., 327).

Dehérain and Vesque have made some very ingenious experiments on the absorption and emission of gases by the roots of plants, from which they conclude that (1) the presence of oxygen in the soil containing roots is necessary for the existence of the plant; (2) the root connected with the stem evolves a quantity of carbonic acid less than the oxygen absorbed; (3) carbonic acid appears not to be derived from the soil, and does not pass to the leaves in order to build up proximate principles by its decomposition into carbon and oxygen (*Comptes Rendus*, lxxxiv., 959–961).

On the whole, the latest experimenting very decidedly favors the belief that plants get all the carbonic acid from which their carbon comes through their leaves, and none through their roots.

Phosphoric Acid as the Food of Plants.

Dr. Petersen, of the experiment station at Regenwalde, in Germany, reports some experiments in water-culture, with the object of determining what proportion of phosphoric acid is essential to the best development of the oat plant. The maximum yield was obtained in solutions which, besides the other essential ingredients of plant-food, furnished 0.071 grams of phosphoric acid to each plant. Plants grown in these solutions yielded each, on the average, 197 seeds, and in the whole plant 10,497 grams dry substance, or 316-fold the weight of the seed. In solutions exactly similar, except that they furnished only half as much phosphoric acid, the plants averaged only ninety-four seeds and 3508 grams dry substance, or 114-fold the weight of the seed.

The results of these experiments agree essentially with those of a number of similar ones reported some time since by Wolff. Both investigators found that when the phosphoric acid did not exceed 0.33 per cent. of the whole weight of the dry substance of the plant, the latter suffered in the development of all its parts. On the other hand, excess of phosphoric acid did no harm, but seemed rather to favor a better development of seed. Wolff calls attention to the difference between phosphoric acid and nitrogen in this respect, the latter, as is well known, having a tendency, when applied in excess, to injure the development of the seeds of cereal grains and cause an excessive growth of stalk, and often lodging of the grain. In this view, it is clear why the excessive use of phosphates which obtains in some farming districts has not proved injurious.

Lime as Plant-Food.

Boehm has studied the plant-nourishing value of calcium salts by experiments on scarlet-runner beans. He concludes that mineral matter is absolutely required for the young plant in order that it may avail itself of the excess of nourishment stored in the seeds, the mineral matter in the seeds being insufficient for this purpose; that without lime salts the growing plants soon wither away and die; and that, finally, lime salts do not participate directly or indirectly in the formation of starch. He also shows that plants may ab-

sorb water and lime salts through their leaves (*Chem. Centralblatt*, 1876, pp. 250, 275, and 808).

ROOT-DEVELOPMENT OF PLANTS.

The study of the root-development of some of our more important agricultural plants is receiving increased attention of late. Very interesting observations have been made by Nobbe, Haberlandt, and Thiel. Fraas has published a little work on the subject; Müller has given a *résumé* of the main points of the present status of our knowledge of the subject in the *Landwirthschaftliche Jahrbücher;* and, finally, Von Nathusius and Thiel have issued a series of six charts, containing no less than fifty-three very fine photographs of roots of various plants as they actually grow in the soil. These include views of the roots of corn, barley, pease, Jerusalem artichoke, potato, and sugar-beet, from which the soil had been removed so as to allow of their being photographed as they grew. They show that while the fine roots penetrate much deeper into the soil than many suppose, yet by far the larger bulk are within a few inches of the surface, and that there most of the feeding of the plants through the roots is done.

Heinrich reports some interesting experiments on the development of roots of barley, oat, and pea plants. The plants were grown in boxes four meters (about thirteen feet) deep, filled with fine garden earth. The oat roots penetrated 2.27 meters; those of barley, 1.9; and of pease, only 0.52 meters. The soil was carefully washed away from the roots, and the latter, as well as the tops, weighed. The weight of the roots of oats was about two thirds that of the tops, without seed; those of barley weighed about one third, and of pease one fifth, as much as the tops.

Frémy and Dehérain find that sugar-beets grown in saline solutions, instead of sand moistened with the same, lived; but instead of producing one large central sugar-forming root, they simply formed a mass of nearly equal rootlets.

MANURES.

Phosphatic Fertilizers.

Dr. Voelcker has continued his reports on these materials, giving analyses of over fifty samples of phosphatic guanos.

Exposed to weather in various climates, bird-dung undergoes change, and guanos of various qualities are produced. The ultimate effect of rain is to destroy the organic matter; the guano then remaining is said to be phosphatic, and contains very little nitrogen. These phosphatic guanos are of great value as materials for high-grade superphosphates. In many cases the bases present are insufficient to form tribasic salts with phosphoric acid, and the phosphoric acid is hence in more readily available forms. The principal supplies are from South America, South Africa, a number of islands in the Caribbean Sea, several uninhabited islands in the South Pacific, and Raza and other islands in the Gulf of California. The richest samples analyzed were those from Raza Island, in the Gulf of California; and Shaw's, Enderbury, Starbuck, and other coral islands in the Pacific. These yielded from 32 to 40 per cent. of phosphoric acid. The latter are, however, apt to be contaminated with coral rock. The Baker, Howland, and Jarvis islands are nearly exhausted. Mejillones guano, a deposit near the coast of Bolivia, is estimated at several million tons. Considering the fact that phosphoric acid is the ingredient most apt to be deficient in our soils and most largely needed in commercial fertilizers, the reports of Dr. Voelcker, which show that immense supplies of this material are accessible in various parts of the world, are very cheering (*Journal Royal Ag. Soc.*, xii., 440–459).

Nitrogenous Fertilizers.

Dr. Voelcker reports also a number of unweathered or partially weathered guanos from new deposits on the South American coasts, which indicate that the supply of these is far from being exhausted. A number of analyses are given in Vol. XIII., pp. 194 *sq.*, of the journal just referred to.

Analyses of eleven samples of Peruvian guano are given in the "Report of the Connecticut Agricultural Experiment Station for 1876." They averaged better than was claimed by the sellers: "Of over two hundred samples of fertilizers analyzed at the station, leaving out a few articles of at present mere local importance, like crude fish-scrap, no others have been found which, as a class, taking into account both quality and price, furnish the valuable ingredients of plant-food so cheaply as Peruvian guano." A great step in ad-

vance has been taken by Messrs. Hobson, Hurtado, and Co., agents of the Peruvian Government for the sale of Peruvian guano in this country, in the preparation of different brands of guano, of uniform though different composition, giving the analysis on each bag, and selling them at prices based upon the guaranteed percentages of valuable ingredients.

Fish-Scrap

Is assuming more and more importance as a fertilizer. Its value is due chiefly to its nitrogen, and in a less degree to its phosphoric acid. Analyses of seventeen samples are given in the Connecticut Experiment Station report referred to. These were sold at prices such as to furnish nitrogen to the user at from 9.4 to 22.1 cents per pound; while in ammoniated superphosphates and the like, as ordinarily sold, the farmers were paying from 20 to 45 cents per pound for their nitrogen. Unfortunately, fish-manures are often ill prepared; their manufacture and use are poorly understood; and they are frequently applied in ways that involve great waste.

Fermentation of Fish-Guano.

The increasing importance of fish and bone manures in German agriculture has led Dr. Pagel, of the Experiment Station at Halle, to undertake a series of experiments to gain light upon the best means of preparing these for use. He recommends very strongly the plan of fermenting them with urine: "The method of fermentation furnishes a most excellent means for transforming the nitrogen in manures of organic origin, which is insoluble and slow in its action, into more soluble and consequently more active forms. It is hence peculiarly applicable to ground bone and fish-guano." He recommends to add about 30 quarts of urine to 100 pounds of bone or guano, and cover the heap with plaster (gypsum) or earth to prevent the escape of ammonia. If this is properly done, the mass will ferment, and the temperature rise to a little above 100° Fahr. The completion of the process, for which three or four weeks should suffice, is indicated by the cooling of the heap.

Potassic Fertilizers.

The *German Potash Salts* are assuming a very important place in the list of our commercial fertilizers. Unfortunate-

ly, the large part of the potash salts brought into this country are of low grades, which contain but little of potassium compounds, and a good deal of common salt and magnesium compounds, which have but little agricultural value, and particularly chloride of magnesium, which may be injurious to crops. The Leopoldshall Kainit, so largely sold in our markets, belongs to this class. This usually contains about 23 per cent. of sulphate of potash, the rest being ballast, on which cost of freight and handling must be paid. It is but little used in Germany. A great part of the product of the mines is said, upon good authority, to be got rid of by exportation to this country. For the evil—a serious one—of importing and using so much of the low-grade potash salts, both sellers and users are responsible. Importers and dealers naturally handle and encourage the sale of the wares on which the margins of the profit are the largest; and being able to get the heaviest percentages on these poor goods, and to dispose of more of them than they could of the better grades, they buy, advertise, recommend, and sell them. A great many farmers say, "Potash salts are potash salts," and take those that can be had at the lowest price, regardless of quality. As long as they will buy low-grade potash salts and other fertilizers because they are "cheap," they must expect to get poor wares at dear rates, and have poor success in using them.

The writer believes the following to be the more important conclusions to be drawn from chemical considerations and practical experience concerning the use of German potash salts as fertilizers. They are taken, with some modifications, from the *American Agriculturist*, Dec., 1877. Details of experiments and analyses upon which they are based (which limited space here excludes) may be found in "Lecture on Potash in Agriculture" and Report of Connecticut Agricultural Experiment Station, in Report of Connecticut Board of Agriculture for 1876.

Experience concerning the use of the German potash salts as fertilizers:

1. Potassium, the basis of potash compounds, is indispensable to the growth of all our cultivated plants. It has at least one specific office in the nutrition of the plant—that of aiding in the formation of carbohydrates (starch). It also

facilitates particularly the growth of leguminous crops, and through them the assimilation of nitrogen. Without a plentiful supply of potash, in available forms, full crops are impossible.

2. The German potash salts afford at present the cheapest and most available supply of potash for fertilizers. They supply also more or less of magnesia and sulphuric acid, which are essential ingredients of plant-food, and sometimes deficient in our soils, and of sodium and chlorine compounds, which latter, though useful in diffusing the potassium through the soil and rendering other plant-food of the soil available, and hence often beneficial, may in certain cases be harmful. The objectionable chlorine will, after a time, leach down and away where it can do no harm.

3. The higher grades will be, in general, most profitable for use in this country, because they furnish the most potassium with the least admixture of inferior materials, on which costs of freight and handling must be paid. The chlorides (muriates) with 80 to 84 per cent. of chloride of potassium, corresponding to 50 to 52 per cent. actual potash, and the sulphates with 70 to 80 per cent. of sulphate of potash, or from 38 to 44 per cent. actual potash, are to be especially recommended. Where common salt and magnesium compounds are wanted, and kainit can be obtained cheaply enough and applied long enough beforehand, it may be used with profit.

4. For potatoes, sugar-beets, or tobacco, the sulphates are preferable. For other crops, or on wet lands, the chlorides, which are cheaper, are equally good. And if the chlorides are applied long enough before the seed is put in—*i. e.*, in the fall—for potatoes or beets to be planted in the following spring, the ill effect of their chlorine upon the quality of the crop will probably be prevented.

5. Potash salts have proved especially useful for fodder crops, as grass and rye; for leguminous crops, as clover, beans, pease, and vetches; and for corn, potatoes, roots, tobacco, and fruits.

6. Potash is most apt to be lacking in light, sandy, and calcareous soils; in those consisting largely of vegetable matters, like peat, muck-beds, and moors, where crops that remove a good deal of potash (such as clover, corn, pota-

toes, turnips, beets, hops, and tobacco) have been repeatedly grown; and where guanos, phosphates, bone, etc., which supply nitrogen, phosphoric acid, and lime, but little or no potash, do not bring as large returns as formerly.

7. In order to secure uniform diffusion through the soil, the potash salts should be applied as long as possible before the crop is sown. It is well to mix with earth, or to compost, before applying, especially if used shortly before sowing the seed, otherwise they may injure the crops. And, in general, potash salts are well adapted for composting with muck, earth, stable-manure, phosphates, fish, and the like.

8. The best results are generally obtained by using potash salts not alone, but with other fertilizers, as superphosphates, guanos, and fish. Mixtures of these with potash salt form "complete" fertilizers. The proper use of potash salts is as adjuncts to other fertilizers.

9. From 200 pounds to 400 or 500 pounds per acre of the higher and 300 to 600 pounds of the lower grades are appropriate quantities.

10. The question of the need of potash in a given soil can be best decided by actual trial. It will be generally advisable to test the question by experiments on a small scale before making large purchases.

The Need of Better Information about Fertilizers

Among our farmers is a vital one. While they are buying medium and inferior articles at prices which bring the cost of the valuable ingredients up to from 50 to 200 per cent. above what they need pay for better ones, foreigners are coming to this country and buying up the best materials, and carrying them off to be used by European farmers who have learned their value. Fish-manures and slaughter-house refuse, in which nitrogen can be had at 10 to 20 cents per pound, and phosphoric acid at from 4 to 8 cents per pound, are being exported by the thousand tons; while our farmers are paying from 20 to 50 cents per pound for nitrogen, and equally high prices for phosphoric acid in the inferior articles that we keep at home. And when we import potash salts we take the poorest, and leave our transatlantic friends the best.

It is bad enough that these precious elements, for lack of which our soils are suffering and our crops falling away, should go out of the country at all. It is too bad that when foreigners come for them they should be allowed to take the best we have, and send us their refuse in return.

COMPOSITION OF PLANTS.

Fodder Corn and Sweet-Potatoes.

Professor S. W. Johnson reports some analyses of sweet-potato and of fodder corn executed under his direction, by Mr. E. H. Jenkins. Except in the larger content of sugar, the composition of the sweet-potato corresponds very closely to that of the common potato. The nutritive values of the two would be nearly equal.

The samples of fodder corn contained, on the average, rather more cellulose, and only about one half as much albuminoids and fats as are given in standard European analyses. This difference is doubtless due to the fact that the corn analyzed was much more mature than that commonly employed in Europe. This inferiority in quality of the older corn is probably more than made up by the larger quantity, particularly if it be fed with judicious admixtures of concentrated foods, like cotton-seed cake, linseed cake, bran, or corn-meal, which will supply the deficient albuminoids and fats. (*American Journal of Science*, xiii., 196).

Buckwheat Straw.

To determine the composition of the straw as grown on the farm, Professor F. H. Storer has made analyses of two samples which turned out very similar to the straw of wheat, oats, barley, and other cereal grain, both in ash and proximate constituents. "A ton (2000 pounds) would contain about 6¼ pounds of phosphoric acid, 40 or 50 pounds of real potash, and 12 pounds of nitrogen." As regards the fodder value, Professor Storer says: "It would seem from the analyses that buckwheat straw, when mixed in small proportion with richer kinds of foods, might, like other straws, be usefully employed for feeding animals in many cases; especially if it were previously softened by steaming or soaking."

Pumpkins, Squashes, Broom-Corn Seeds, Weeds, etc.

Professor Storer has also analyzed several specimens of pumpkins and squashes, and finds them, on the whole, quite rich in nitrogen. He considers the pumpkin as "competent to supply a good part of the albuminoid matters which corn-stalks lack." Professor Storer also gives a large number of analyses of seeds of broom-corn, of weeds occasionally used as human food—as the dandelion, nettle, common plantain, purslane, and pigweed—and of blue-joint grass and reed canary-grass; for the broom-corn seeds are inferior to oats, etc., as food for stock, because poor in albuminoids though rich in carbohydrates. The weeds have considerable fodder value, but are unfit for cultivation because they are inferior to the plants with which they would have to come in competition. Still when gathered, as they often are, they ought to be saved and fed rather than composted, burned, or thrown away. The blue-joint grass was poor; but the reed canary-grass proved much better than was expected, is measurably rich in nutritive ingredients, and "as a substitute for our wild bog grasses it could doubtless be grown with advantage in numberless localities in this country" (*Bulletin* of the Bussey Institution, ii., 51, 81, 115, and 130).

Sugar-Beet Culture and Beet-Sugar Making.

The attempts in this direction in the United States have not thus far proved strikingly successful, though favorable reports come from California and elsewhere. One great trouble has been the putting-up of costly factories before the supply of beets good enough to pay for the working was made sure of.

Mr. H. C. Humphrey, who has made this subject, from the chemical standpoint especially, a study for several years, in this country and in Europe, has joined with Mr. Joseph Wharton in a very extensive experiment upon the estate of the latter in Balsto, N. J. The raising of the beets is being first tested, though a small experimental factory for making the sugar has been erected. Concerning the prospects of profitable manufacture, Mr. Humphrey makes estimates in brief as follows: A manufactory to consume 15,000,000 pounds of beets in one hundred days would cost about $60,000,

and the stock of bone-black $2250. The current annual expenses, including labor, materials, and incidentals, reckoning beets at $4 per ton, and interest on capital at 7 per cent., would be some $82,664. The returns for sugar, press-cake, molasses, and residues for fertilizers, reckoning sugar to yield 8 per cent. of weight of beets, and to bring 8¼ cents per pound, and press-cake at $4 per ton, would be $107,233, leaving a profit of $24,569. This Mr. Humphrey considers high for probable expenses and low for returns.

NUTRITION OF ANIMALS.—STOCK-FEEDING.

The experimental investigations in this direction are increasing in number, range, scientific accuracy, and practical value. Nearly all of the most useful work of the past year has been done in the German experiment stations. Little that is absolutely new in principle has been discovered, but much has been done to establish, amplify, and make capable of wider application in practice the principles already propounded.

Sources of the Fat of the Animal Body.

It is common to see the albuminoids of foods classed as "flesh-formers," and the carbohydrates as "fat-formers." This is in accordance with the theory of Liebig, that, aside from the fats of the food, the carbohydrates sugar, starch, etc., are the main source of the fats of the body and the milk. But of late many physiologists—notably Voit—have maintained that animals get their fat from the albuminoids, and not from the carbohydrates of their food. It is well settled that the albuminoids can and do by their decomposition supply a good deal of fat for storing in the body and making milk. Whether the carbohydrates do the same is still an open question. Professor Wolff, in his lately published "Ernährung der Landwirthschaftlichen Nutzthiere" (Nutrition of Animals Useful in Agriculture), gives a very comprehensive summary of the latest experimental evidence upon the subject, from which he concludes that carnivora cannot, herbivora may, and swine probably do, produce fat from the carbohydrates of the food. Professor Henneberg, at the meeting of German naturalists and physicians at Hamburg in 1876,

expressed his opinion that fat is formed from carbohydrates by swine; and this would probably prove to be the case with other animals. With this view Dr. Gilbert, of Rothamstead, seemed to agree. Henneberg, on the same occasion, presented some calculations which led to the inference that 100 parts of albuminoids may produce 51.4 parts of fats.

Effect of Fodder upon Milk Production.

The experiments of Kühn at Moeckern on the effects of different kinds and amounts of food upon the production of milk by cows are coming to assume great importance. Eight series made during the years 1867–74 have now been reported. These include eighty-four single experiments with twenty-six cows. Detailed accounts of those of 1870–73 were commenced in the *Journal für Landwirthschaft* for 1874, and have just been completed in the volume for 1877. Only a brief report of the eighth series has been published. The later ones are not yet published. Dr. Kühn has, however, given, in a report of the work of the Moeckern station to 1877 (*Landw. Vers. Stat.*, xxii., 133–143), a summary of results to that time. It appears that after the ration has reached a certain amount of food of fitting composition, (1) increase of the food brings an increase of the total yield of milk; (2) the "richness" of the milk, the percentage of dry or solid matters, increases at the same time; (3) there is a limit to this improvement in quality and amount of the milk, varying with different breeds and individuals; (4) changes in the composition of the rations, in the proportions of albuminoids, carbohydrates, and fats they contain, do not produce corresponding changes in the composition of the solid matters of the milk. The proportions of casein, albumen, fat, and sugar rise and fall parallel with each other; at least, the variations are slight, and not parallel with those in the ingredients of the food.

In short, it does not seem practicable, by altering the quality of the food, to increase, for instance, the fat at the expense of the casein of the milk; to change a "cheese cow" into a butter cow, or *vice versa*. A few exceptions to this rule have indeed been found. Two cows out of thirty experimented upon at Moeckern and Hohenheim have shown an evident and some others an apparent relative increase in

the fat of the milk when material rich in albuminoids, particularly palm-cake freed from oil, was added to the ration.

Changes in the Milk during the Period of Lactation.

The Moeckern experiments have also given more accurate data upon this subject than have been ever before obtained. In general, the total yield of milk decreases as the milking period advances. The shrinkage is exaggerated by poor feeding, and can be prevented in part by adequate food and consequent maintenance of the body in good condition. The richness of the milk, the percentage of solids, increases. The increase can be aided by proper feeding, and partly prevented by inadequate nourishment and consequent falling-off in condition. As regards the changes in relative proportions of solid matters, their ratios to each other, the proportion of fat seems to decrease and that of casein to increase somewhat; that of albumen diminishes, while the sugar remains constant.

GENERAL CONCLUSIONS FROM EXPERIMENTS ON EFFECTS OF FOOD UPON MILK PRODUCTION.

Among the general principles deducible from the later experimenting on milk-production by cows, two of the weightiest are that of the food ingredients the most important as factors of the milk-production are the albuminoids, and that the production is controlled to a much greater extent than is commonly supposed by the bodily condition. And these two principles are, in fact, corollaries of the single, broader one developed by late research in this department of animal physiology—that the function of the lacteal glands is not entirely, or even mainly, that of filters through which certain ingredients of the blood are secreted as milk, but that they themselves produce, by metamorphosis of their own substance, the larger part of the solids of the milk; that, as Voit says, "the milk is essentially this organ, liquefied by fatty degeneration." It seems fairly well settled that all the casein and a good part of the fat and sugar of the milk are products of metamorphosis of the milk glands; that of the fat and sugar supplied by the blood, a portion results from similar metamorphoses in other parts of the body; and hence only a small residue of fat and sugar can come directly from the food.

Accordingly, to effect any considerable changes in the milk, we must first work upon the body, and provide it, and particularly the milk glands, with material for making the milk; and since albuminoids are the chief tissue-formers, they are most important for producing casein and fat in the milk. It is clear, then, that to produce a good yield of milk the animal must be kept in good condition by proper feeding; that the food, to be most economical, must contain the proper proportions of albuminoids, carbohydrates, and fats; and that the composition of the milk is decided by the peculiarities of the breed and individual rather than by the food. The practical application of these principles is apparent. For quality of milk select proper breeds; for amount, good milkers. Suit the food to the wants of the animal, and feed well, but not over richly.

Other Feeding Experiments.

Of those reported during the past year we have only space for the briefest reference to some of the most important. Among them are experiments on the digestive capacity of the horse, by Wolff, at Hohenheim; on the digestion of various foods by sheep, by Weiske at Proskau, Wolff and Kellner at Hohenheim, and Wildt at Kuschen; and on the digestion of different foods by swine, by Wolff, by Wildt, and by Heiden, at Pommritz. Full accounts of these are given in the volumes of the *Landwirthschaftliche Versuchs-Stationen Journal für Landwirthschaft*, and *Landwirthschaftliche Jahrbücher* for 1876 and 1877.

The Digestive Capacity of Horses.

Wolff reports experiments on the digestion of hay, straw, and oats by a horse as compared with sheep. The horse digested a little less from the hay and straw than the sheep. With oats the digestion was essentially the same by both. From his own and other experiments Wolff concludes that all the domestic animals — horses, cows, sheep, goats, and swine — digest the concentrated food (grain, roots, etc.) and the young succulent forage plants about alike. Of coarse foods, sheep digest a somewhat larger percentage than horses.

Digestion of Foods by Swine.

Experiments are reported by Wolff, Wildt, and Heiden, who with assistants have tested the digestion of quite a list of materials, such as barley, maize, pea-meal, cocoa-nut cake, potatoes, roots, milk, flesh-meal, fish-guano, and in one case cockchafers. Sour milk is not wholly digested by swine; but it seems to increase the digestion of other foods, as grain, fed with it. Cocoa-nut cake proved a palatable and useful food for swine. The same is true of cockchafers, dried and ground. The digestibility of flesh-meal made of the residue left from the preparation of Liebig's meat-extract in South America has been tested quite extensively. Wolff found, as the average of seven experiments, 96.6 per cent. of the albuminoids and 87.3 per cent. of the fat of the flesh-meal to be digested by pigs.

Digestion of Foods by Sheep.

Experiments on the digestive and nutritive values of various materials fed to sheep are reported by Wolff and Kellner, Weiske and Wildt. The most interesting results are those obtained with the use of animal foods, blood-meal, flesh-meal, and fish-guano. The general object of these experiments has been to test the digestibility and nutritive value of these foods, and the question whether they can be used to advantage to supply nitrogenous material in fodder for herbivorous animals. There is no reason, in the nature of the case, why they should not; and the several accurate trials that have thus far been made coincide with former experience in showing that the flesh-meal made of the residue left from the preparation of Liebig's meat-extract, dried blood, and fish-guano, are very easily digested; that though sometimes not very palatable at first, yet the animals soon get to like them, and that they form a very valuable food. In feeding fish-guano to sheep Kellner found 90 per cent. of the nitrogenous substances, 76 per cent. of the fat, and 15 per cent. of the mineral matters digested. Wildt found that sheep digested 95 per cent. of the albuminoids, and 98 per cent. of the fat of flesh-meal.

Value of Animal Waste as Food for Stock.—Fish-Scrap.

From what has been said, it is clear that fish-scrap, meat-scrap, dried blood, and the like are certainly valuable foods for sheep and swine, and probably for neat cattle. What makes them especially so is that, aside from their concentration and their easy digestibility, they consist mainly of nitrogenous matters and fats, the most precious ingredients and the ones most apt to be lacking in our common fodder materials. They will be used most profitably when mixed with foods poor in the albuminoids which it furnishes. Such are poor hay, straw, corn-stalks, corn, potatoes, and roots. The latter can thus be made into the best kind of food, and the fish-scrap at the same time be improved as a fertilizer. One great difficulty in the way of feeding fish-scrap, dried blood, and meat-scrap has been their bad odor and taste, particularly after decomposition has set in. Of late, however, methods have been devised for preparing these materials in forms more palatable and less prone to decay. Meat-scrap is now offered in the market as light in color, nearly as fine and free from odor and tendency to decay, and fully as wholesome in appearance, as corn-meal. Two new processes for extracting oil from fish—Goodale's and Adamson's—are just coming into use, and give promise of furnishing a fish-scrap which can easily be made into an excellent food for stock. One great advantage of the fish meals made by these latter processes is that they have all, or nearly all, the flesh of the fish, and comparatively little else. Samples of both kinds, lately analyzed, have yielded over ten per cent. of nitrogen. A fish-guano made by Goodale's process gave some ten and one-fourth per cent. of nitrogen, and a little over seven per cent. of phosphoric acid. The fish-guano which has proved so valuable for food in European experiments was made of the heads and backs of codfish, and contained a much larger amount of phosphoric acid. Our products must be much better, because they have less phosphoric acid—that is to say, less bone—whose presence is objectionable.

We have seen what a loss comes to our agriculture from the exportation of meat-blood and fish products, as well as from the improper use as fertilizers of those which we keep

at home. In view of their worth as food for stock, the loss is still greater. As long as these wastes continue, farming must suffer. Rational economizing of such resources as these will be among the best means for its recuperation.

Practical Inferences from Feeding Experiments.

In general, the result of the year's work confirms the principle stated in previous summaries of the *Annual Record*, but too little understood by farmers in this country, that economy in feeding requires that the ration shall contain digestible albuminoids and carbohydrates in the proportions adapted to the specific wants of the animal and the purpose for which it is fed.

Comparing the results of late European experimenting with the ordinary practice of feeding in this country, it is manifest that we waste a great deal of food-material, and that this waste is due, more than to anything else, to the wrong proportions of ingredients in the fodder we use. From wrong choice of crops for raising (as, for instance, growing too little of nitrogenous crops, like clover, lucern, beans, and pease), from inadequate manuring of those we do raise, and from letting forage crops stand too long before cutting, our fodder materials lack nitrogen. We have concentrated foods, such as linseed and cotton-seed cake and meal, meat-scrap, and fish, which might supply this lack. But our farmers do not understand their value, and they are shipped by the hundreds of tons to Europe, where they are appreciated and properly fed. This is only one of many illustrations of the necessity of science for the best development of our agriculture. A most encouraging sign of the times is that farmers have come to feel this need, are calling for scientific investigation, and are applying its results in their practice.

ENGINEERING.

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RAILROADS.

From a record of the year's progress, as chronicled in the *Railroad Gazette*, we may affirm that in the field of railroad construction there has been reasonable activity, the increase in the mileage of the country having been about 3 per cent. The *Gazette* records 2111 miles as the actual record of new construction during 1877, or about 10 per cent. less than the figures of the preceding year. Most of the new roads, it is further noticed, were short, and of purely local importance.

In railroad legislation, the most memorable event of the past year was the decision of the Supreme Court of the United States in the so-called "Granger" cases, in which the principle was affirmed that state legislatures possessed the right to regulate and limit the rates charged by railroad companies where they have not parted with that right by charters. Another legal decision of importance, detailed by the *Gazette*, is that permitting the elevated-railway companies of New York City to proceed with the construction of their roads through the streets of that city without further hinderance. That the companies have not been slow to avail themselves of the privileges accorded them appears to be evinced from the vigor with which they are forwarding their plans; the probabilities being that the several rapid-transit roads will be practically completed and in operation before another year has passed, thus deciding the debated question of the practicability of elevated (as contrasted with underground) railroads for the requirements of large cities.

The *Gazette* closes an elaborate statement of railroad history with the following comments: "The year closed much more cheerfully than it opened. . . . The prospect for the

new year is favorable. . . . The whole country is apparently convinced that it will have to accept low prices and small profits, and is satisfied to accept these conditions. No sudden return of great prosperity can be looked for, but a gradual return to better times is now held to be a sufficient cause for cheerfulness."

THE CANAL ACROSS THE AMERICAN ISTHMUS.

The constant agitation of this problem by the friends of rapid maritime transit will doubtless some day bear its legitimate fruit in the actual undertaking of a canal across one of the many routes surveyed by American and other engineers, although but little progress towards its solution has lately been made. The subject appears lately to have been attracting a considerable share of attention in France, the interest being at present centred upon the Darien route. De Lesseps, whose name figures prominently in the present discussion of this important project, advocates a line ascending the Tuyra or Darien River from the Pacific side as far as the island of Piriaque, from which point a straight cutting, 16,200 meters long, will connect the Tuyra with the Chucunaque near the point where the Tupisa flows into this latter river. The line proposed would then ascend the Chucunaque for 11,400 meters; then, turning to the northeast, would continue up the valley of the Tiati to a point where its projector, for reasons of economy, proposes to construct a tunnel rather than continue a deep cutting. This tunnel would pass to the south of the Peak of Ganol, under the remarkable ridge from which, on the one side, the Taquesa, the Tupisa, and the Tiati flow down towards the Pacific, and, on the other, the Tolo and the Acanti to the Atlantic. On emerging, the canal would continue through an open cutting about ten kilometers long down the valleys of the Acanti and Tolo to the deep waters of Port Candi. The probable length of the tunnel is estimated at between thirteen and fourteen kilometers, and the cost of making the whole canal at 600,000,000 francs (about $120,000,000). A surveying party, under the command of Lieutenant Wyse, of the French navy, is at present on the ground, working out the feasibility of the proposed route.

Having solicited of Mr. John C. Trautwine, a gentleman

whose eminent professional standing and intimate familiarity with the physical geography of the whole isthmus entitle his statement to be taken as authoritative, an opinion of the route now being explored by the Wyse party, he replied that this undertaking would prove to be an utter failure, and took occasion to reiterate an assertion made by him twenty-five years ago, on returning from his own solitary expedition in search of a route in that region, that there is no reason whatever upon which to base a hope of obtaining a favorable line across any portion of the Darien Isthmus. He insists upon his oft-repeated statement that no route exists that could be executed for less than about $300,000,000. He would reject the temporizing policy which deludes itself with the vain hope of new discovery upon ground that has been surveyed and resurveyed, and face the difficulties of the problem. He favors the cutting of a direct line from the Gulf of San Blas, on the Atlantic, to the mouth of the river Bayano, on the Pacific. This is the shortest route that exists, being only about thirty to thirty-five miles long: it would, however, require a ship-tunnel possibly ten miles long.

THE MISSISSIPPI JETTIES.

From the official statements of the government engineers who are commissioned to inspect the work upon the jetties at South Pass, substantial progress appears to have been made during the past year; and everything appears to indicate the complete ultimate success of the undertaking and the triumph of the views of its advocates. From the latest published report of Captain Eads to the South Pass Jetty Company, we abridge the following concerning the more important results obtained. After a preamble relating the difficulties of the task, and affirming that the theories upon which the system of working was undertaken have been fully confirmed, the report announces that the concentration of the water flowing across the sand-bar at the mouth of the Pass by the jetties has created a channel over two hundred feet wide, and in no place less than twenty feet deep, where only about eight feet had previously existed; that the concentration of the water flowing over the shoal in the river at the head of the Pass created a channel over four hundred

feet wide, and in no part less than twenty feet deep, with the central part thirty feet deep, where but fourteen to fifteen feet had previously existed; that the temporary deposit which had formed in the Pass and between the jetties during the time in which a portion of the flow into the Pass had been interrupted by the work at its head has, since the restoration of the normal flow through the new channel at its head, by its removal caused the Pass to enlarge again; an action that has, since this restored flow began, removed from between the jetties in the last three months over half a million cubic yards of deposit, and established through more than half the length of the jetties a much larger and deeper channel than had ever previously existed, the size of which is already, throughout more than two thousand feet, twenty-eight feet deep by three hundred feet wide, while for many hundreds of feet it exceeds thirty feet deep by three hundred and fifty feet wide; and, finally, the report affirms—what is of the last importance to the permanent success of the work—that the gulf current athwart the jettied mouth of the Pass effectually prevents the re-formation of the bar in advance of the jetties by deepening the outer slope of the bar, and sweeping away any such portion of the discharged sediment as the river current fails to carry to unknown distances seaward.

The fact is worthy of mention, finally, that on the 1st of November, 1877, the steamship *City of Bristol*, of the well-known Inman line, passed through the jetties without detention and without touching. Her draught was twenty-one feet eight inches, and the tide at the time was two and a half inches below "average flood-tide," which is the plane of reference established by the United States engineers.

OTHER AMERICAN ENGINEERING WORKS.

Concerning the East River Bridge, the Hudson River Tunnel, the New York elevated railroads, and the Poughkeepsie Bridge (which are probably the most noteworthy domestic engineering works in course of construction), we have nothing especially noteworthy to record, save that all are making gradual progress towards completion.

IMPROVEMENT ON THE UPPER MISSISSIPPI.

The last year witnessed, also, the completion of the canal constructed by government engineers with the object of overcoming the obstruction to navigation caused by the Des Moines rapids in the Mississippi at Keokuk, Ia. The following account of the character and importance of this work may be found of interest. The canal extends along the Iowa shore from Keokuk to Nashville a distance of seven and six-tenths miles. It is three hundred feet wide in embankment and two hundred and fifty feet wide in excavation; minimum depth of water, five feet; maximum depth, eight feet, which is sufficient to float the largest steamers that ply the Upper Mississippi. Entire fall in length of canal, 1875 feet. There are two lift-locks and one guard-lock, each three hundred and fifty feet long and eighty feet wide on top, solidly built of cut-stone masonry. Sluices of ample capacity to control the surplus water carried into the canal during the flood season are built around the locks. The cost of the work thus far has been $4,281,000, and $100,000 will still be required to finish it. The *Engineering News* affirms that this work is of incalculable importance to the navigation of the Mississippi River, as it removes the only obstruction that remained between New Orleans and St. Paul.

THE MADEIRA AND MAMORÉ RAILWAY.

In future commercial possibilities, the work of the building of this railroad (a contract for which was last year given by the agent of the Bolivian Government to certain American capitalists) is doubtless the most important enterprise that has lately been undertaken. The successful accomplishment of this project will have for its practical result the opening of a region of South America vast in extent, and of vast though undeveloped mineral and agricultural resources, but which, by reason of almost insurmountable natural obstacles, has been heretofore practically isolated from commercial intercourse with the world. The object of the proposed improvements, which are on a scale of great magnitude, is, by the construction of a line of railway, to bridge a gap of about one hundred and eighty miles, in which the existence of numerous falls and rapids opposes at present a complete

barrier to commercial intercourse, and thereby permit the movement of trade down the Madeira and the Amazon to the Atlantic.

The following will give the essential features of this important work: "The road will run along the eastern shore of the Madeira River, in Brazil, from the head of navigation below the rapids to the navigable water of the Mamoré River (a branch of the Madeira) above. The Madeira has its source on the great water-shed of Bolivia, east of the Andes; leaves Bolivia at the northeastern point, and runs across the table-lands of Brazil to the Amazon, which it joins at Barra, about seven hundred miles from the Atlantic. A series of falls, however, render the river useless for a distance of one hundred and eighty miles. The Mamoré is a branch of the Madeira, and begins above the falls on the border of Bolivia."

The object of the proposed railroad, as has been before explained, is to bridge over this gap of one hundred and eighty miles that nature has interposed in this region between it and the commerce of the outer world. The area of country that the road will tap is estimated to be about 480,000 square miles; and of the country itself, the salubrity of its climate, its mineral resources, and agricultural capabilities, the most flattering accounts are given. It is said that silver, gold, lead, copper, salt, and nitre are abundant; and that the soil will produce cotton, sugar-cane, tobacco, coffee, cocoa, indigo, and other important staples in profusion.

The grant received by the Bolivian Navigation Company (under whose auspices the work of improvements is being carried on) from the governments of Brazil and Bolivia embraces a million acres of land, and the navigation of all the waters of Bolivia for the period of ninety-nine years, with the additional concession that no other company shall be accorded the right to build a railroad around the rapids for the next fifty years. The possible value of this monopoly in the future cannot be estimated; and since the contract for the building of the road which is to unite this country in commercial relations with the rest of the world has been accorded to American engineers, the hope is widely expressed that this country may take such measures as will direct

the current of this prospective rich and abundant traffic to our own ports, to the advantage of American manufacturers.

At the time of this writing, the steamer *Mercedita* had sailed from Philadelphia with a large number of engineers and laborers, and the first load of supplies and machinery, for the scene of operations. This vessel is to be followed by others, and monthly communication between the base of supplies and the Madeira will be kept up.

THE SUTRO TUNNEL.

The latest advices indicate that the great tunnel into the Comstock silver lodes is gradually approaching completion. At the time of this writing it is officially announced that the tunnel-heading had penetrated into paying ore, and had been driven a distance of 18,400 feet into the mountain. This would bring the tunnel, as near as may be estimated, to within less than one hundred feet of the great combination mining-shaft, which, when reached, will practically complete the undertaking and determine its value. The following statements of the nature and history of this enterprise may, in view of the above facts, be of interest:

The object of the Sutro Tunnel is to facilitate mining operations in the Comstock lode, the difficulties and expensiveness of which are very serious. The mines have reached a depth of from 1000 to 2500 feet; and the cost of pumping to keep the workings free from water entails an annual expense of \$2,000,000 or \$3,000,000. This fact, and the circumstance also that the temperature in the deeper portions of the workings reaches as high as 120°, render mining operations enormously expensive. These difficulties the Sutro Tunnel is designed to obviate by tapping the workings at a depth of about 1800 feet from the surface, creating, therefore, a new surface for ventilation and drainage at the 1800-foot level of the mines, by which it is expected (as the water will be drained off, by the natural flow through the outlet provided, to the depth of 1800 feet) that the cost of pumping will be largely reduced, and that the means of ventilation which it will provide will so far reduce the temperature as to enable the miners to work in comparative comfort. In addition to these obvious advantages which it is expected to realize from the tunnel, there are others of considerable commercial

importance expected to flow from it. It is expected, for instance, that the tunnel will form the great highway or outlet for the ores of the Comstock, which are at present hoisted to the surface, and thence transported to the mills on the Corson River, a distance of some twenty miles. By the erection of mills at the mouth of the tunnel, the cost of transportation (which is now very considerable) could be greatly reduced. It will also render possible the profitable working of low-grade ores, of which enormous quantities remain in the mines untouched.

Work on the tunnel was commenced on October 19, 1869, and has been steadily continued until the present, when but little more is required to complete it. The total amount expended on the work thus far will foot up to about $3,000,000. Some $500,000 more will be required, on completion of the tunnel work, to provide it with a double track, and bring it into complete working order with the paraphernalia for wire-rope transmission, etc.

STEAM-MOTORS ON CITY RAILWAYS.

In addition to the satisfactory progress made during the past year towards the completion of the elevated-railway plant, designed to secure rapid transit in New York City, the substantial progress made in other cities in introducing steam-cars on the street-railways is worthy of special notice. This movement was inaugurated by the Market Street City Passenger Railway Company of Philadelphia, which in the month of March, 1877, put into operation seven steam-cars, with the avowed purpose of giving them a thorough and continuous practical test. The experiment appears up to the present time to have proved quite successful, as all the cars have continued in operation since they were put on without difficulty or objection. The cars are noiseless in operation, and the anticipated trouble from the escaping steam has proved to be groundless. The operation of these cars has shown, it is affirmed, a notable economy over the common plan of horse traction which they replace. The success of this experiment appears to have attracted attention to the question, and a considerable number of steam-cars have been introduced during the past year upon the street-railways of other American cities.

The cars above alluded to are of the self-contained type, in which engine and car are combined. Apropos of this subject, which naturally provoked much discussion in the engineering journals, the *Railroad Gazette*, whose professional opinions are entitled to high consideration, intimates that the most rational solution of the steam street-car problem will be found in a light steam-engine, which may be coupled to and detached from the common street-cars as horses are. This plan has been tried in several cities (Baltimore, Philadelphia, New Haven, Dubuque, Havana, etc.) with good results. It would admit of the use of the present cars, which the self-contained steam-cars do not permit (and this fact, incidentally remarked, is one of the most serious obstacles in the way of introducing steam on the city railways, since the substitution of specially constructed steam-cars would render the present rolling stock, in which large capital is locked up, practically valueless). An accident to either the car or engine of one of these self-contained cars lays up the whole apparatus for repairs; while an accident with the independent system might lay up a car or an engine, but would leave one or the other free for use, as the car could be coupled to another engine, or the reverse.

The subject also appears to have attracted an unusual share of attention abroad, especially in England and France. In Paris, for example, not less than thirty-five steam-motors were in daily use about August last; and new lines coming to the very heart of the city were under construction, which were to be operated by steam. It appears probable, therefore, that during the past year we have witnessed the initial steps of an innovation destined shortly to replace very largely the old system of horse-power traffic in cities.

THE PATENT MODEL SYSTEM.

A question which vitally concerns the inventors of the country, and which has given rise to much discussion *pro* and *con*, is the proposition to abolish the system, so long in vogue, of demanding models of inventions to accompany the application of the would-be patentee. The recent destruction by fire of a portion of the Patent-office building, in which these models were stored, and the destruction of a large number of them, gave the opportunity for the oppo-

nents of the existing system to begin a war against it. The main arguments of those who favor the abolition of the model-system are, substantially, that in the great majority of cases a model is unnecessary, since the invention can be quite clearly and understandingly shown by a properly finished drawing; that the rule making models obligatory, as the law now practically stands, is an unnecessary and burdensome tax upon the resources of the inventor class, the cost of models being often so great as to deter inventors from patenting their inventions; that, in view of these facts and others of minor importance, it is unjust to tax twenty-nine inventors with the expense of a model which experience has shown to be necessary only in the thirtieth case; and that the system should be so changed as to require inventors to present models only in cases where, from the nature of the subject, the ideas of the would-be patentee cannot be properly understood by drawings alone, or in cases of suits in interference, etc., where they may be reasonably supposed to be necessary and of service. The conservative element that favors the continuance of the *status quo* urges in substance, that, so far from being a hardship to the inventor class at large, it is really the best and only trustworthy safeguard against the wholesale pirating of patented inventions; and that, admitting that models may be in many cases dispensed with as unnecessary, and that in certain of such cases the rule requiring models may work individual hardship, the abandonment of the general rule would be unwise, and would operate disastrously upon the inventor class by bringing about a general depreciation of property-value in patents —a result which, it is strongly maintained, would be sure to follow the invitation to fraudulent practices which would be afforded by the absence of models, and the consequently greatly multiplied difficulties the examiners must then have to contend with in deciding the question of originality.

It appears probable, at the time of this writing, that the discussion may result in a modification of the existing laws on the subject, by which the Commissioner of Patents will be vested with larger discretionary powers to demand models only where, in the judgment of examiners, they are deemed desirable or necessary.

SHIP-CANAL PROJECT ON THE SEINE.

The preliminary arrangements are being made at Havre, at the time of this writing, for the construction of a maritime canal from that port, touching at Harfleur, and joining the Seine at Tancarville, a point on the river about sixty miles below Rouen. This improvement is projected for the purpose of obviating the dangers of the navigation of the Lower Seine by reason of fogs, the shifting sands, and the violence of the tidal wave. According to description, the canal will consist of a single section of about seventeen miles in length, the western outlet of which will be in the Eure Dock at Havre. The plans adopted contemplate a canal with a minimum breadth of twenty-five meters. Plans have also been elaborated for the deepening of the channel of the Seine between Paris and Rouen to 3.20 meters; and the canal between Havre and Harfleur is designed to have a depth of 4.5 meters, to accommodate the passage of vessels of considerable draught of water. The work is estimated to cost about 21,000,000 francs, which will include all accessory works, the planting of the banks with trees, the construction of a branch five hundred meters long to connect the port of Harfleur with the canal, and a basin of five hundred by sixty meters at Havre. We make the above statements on the authority of *Saward's.*

THE ALGERIAN INLAND SEA.

This project, which received notice in our last year's *Record*, appears to be further from realization than ever. Last year it appears to have been the subject of considerable discussion in French scientific circles, and to have aroused some very serious objections to its advisability. The objectors are MM. Naudin, Dumas, and Daubrée, and their objections are based upon sanitary grounds. Their arguments as quoted in the London *Engineer* are as follows: To fill with salt-water the shallow basins of the region which it is proposed to convert into an inland sea would be equivalent to reproducing in Algeria all the evil features of a series of marshes. The deepest portion would, it is admitted, not exceed eighty feet in depth, and the whole coast-line would be so shallow as to be but little else than a marshy bank, which, under

the influence of a tropical sun for eight months of the year, would doubtless become a focus which would develop and distribute all the evils of malaria. M. Roudaire, the originator and champion of the scheme, has made a personal examination of the region between Biskra and the Gulf of Gabes, and estimates that his project will necessitate the removal of some 20,000,000 cubic meters of sand, the probable expense of which will be about 30,000,000 francs. The alleged advantages of this project we have detailed in previous volumes.

FLOODING OF THE SAHARA.

Mr. Donald Mackenzie has not yet abandoned his pet scheme for opening Africa to commerce by turning the waters of the Atlantic into the African desert. His present plan, as expressed before the Chamber of Commerce and the Philosophical Society at Bradford, England, is to utilize the vast plain or basin known as El-Jaf, containing an area of 80,000 square miles. This vast depression, which is affirmed by Mr. Mackenzie to be some two hundred feet below the ocean-level, and to have been formerly connected with the Atlantic Ocean by a channel now blocked up with sand, it is proposed to restore to its ancient condition as an arm of the sea by removing this barrier, and thus open a navigable highway for the commerce of the world to the very heart of Africa.

ANOTHER AFRICAN PROJECT.

The latest engineering scheme affecting this continent originates with Sir Samuel Baker, who proposes a plan by which not only the water of the Nile, but the silt (of which the greater portion is now wastefully deposited in the Mediterranean Sea), shall be turned to good account as a fertilizer of the deserts of Nubia, Libya, and the Soudan. He proposes in the London *Times* the construction of a system of engineering works by which a portion of the Nile flood-water, with its annual burden of soil robbed from the fertile slopes of the Abyssinian plateaux, shall be diverted into these deserts, where it may deposit its rich sediment on the sands, and also irrigate them, so as to transform a desert into "cotton-fields that would render England independent of America." This desideratum he proposes to accomplish

by the erection of suitable dams and sluices at different points of the Nile—as, for example, at the cataracts. These structures, he concludes, would also greatly improve the navigation of the river.

THE SIMPLON TUNNEL PROJECT.

This project is still the subject of newspaper discussion, though nothing of a definite nature has transpired during 1877 concerning it. We may record, however, the current report that a French company, having secured important concessions from the Italian Government, seriously contemplates the undertaking. The projected line of road would commence at Brigue, which would thus become the international entrance station to the tunnel, which, according to the statements of the projectors, would have a length of 18,340 meters. The *Annales du Génie Civil* affirms that the scheme is so far advanced that preliminary surveys for the tunnel-work and for the construction of the approaches are now in course of execution.

DRAINING OF THE ZUYDER-ZEE.

The engineering journals noted during the past year that active preparations were being made for the commencement of the long-projected work of draining the Zuyder-Zee. This work, which has been alluded to in former volumes of the *Record*, is of prodigious magnitude. It will require, according to estimate, sixteen years for its completion, and will cost about 335,000,000 francs.

MISCELLANEOUS.

During the past year, a commission of engineers appointed by the Belgian Government to decide upon the merits of the several forms of continuous train-brakes reported in favor of the Westinghouse system, after an extended series of experimental trials, and recommended its adoption upon all the Belgian state railroads. This recommendation, we understand, has since been carried into effect.

The hopes of the friends of Chinese progress have received a severe check in the action of the Chinese Government in regard to the Shanghai and Woosung Railroad, the first (and likely to be the last for some time to come) and only railway

in the Chinese Empire. For reasons best known to themselves, the authorities, after securing possession of the road by purchase, entirely suspended its operations; and, if report be correct, dismantled the road and destroyed the rolling-stock.

The Peruvian Government last year entered into an agreement with Mr. Henry Meiggs, the well-known contractor, for the construction of a drainage tunnel to make accessible the rich but long-abandoned silver-mines of Cerro de Pasco. This work, which is one of great importance, will probably be seriously affected by the death of Mr. Meiggs, which lately occurred. The St. Gothard tunnel has made satisfactory progress during 1877.

TECHNOLOGY.

By WILLIAM H. WAHL, Ph.D.,
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THE DUPUY DIRECT PROCESS.

This process, which was first publicly announced at the monthly meeting of the Franklin Institute in November, 1877, has been for nearly a year experimentally tested at Pittsburgh, and with such promising results as to justify one of the largest establishments of that city in erecting a plant, consisting of crusher, mill, furnaces, forge, etc., to test it commercially. The following gives in brief the novel features of the plan. Mr. Dupuy makes a suitable mixture of ground ore, flux, and coal-slack (and alkalies), and introduces the same into sheet-iron canisters of annular form, so that the heat of the furnace may penetrate the mixture from both the outer and the inner surface. The object sought to be attained by this plan is to secure the advantages of the close pot by employing a protecting envelope which will withstand the high heat required for the reduction, and which, when the operation is completed, may be welded up with the metal.

The inventor describes three methods of working the process, according to the purpose for which the metal is designed:

1. For steel-making, the canisters are charged on end into the furnace, on a layer of coke a few inches in thickness. When reduced (in from five to seven hours), it forms a very firm metallic mass, which is removed and hammered, or thrown into a squeezer and rolled into muck-bar. The latter is reheated, cut up, piled, and put into the steel-pot.

2. The reduced metal may be remelted in a Siemens open hearth, with or without the usual carbonizing bath of pig and spiegel.

3. The metal, when reduced, may be melted down in the same furnace and carbonized with pig-iron. The following

details may be instructive: "Canisters of No. 26 sheet-iron, fifteen inches outside diameter and thirteen inches high, with a tube six inches diameter passing through and through in the centre, including top and bottom, will weigh six pounds. They will hold one hundred and sixteen pounds each of 67 per cent. ore, besides the carbon and fluxes. Each canister will yield from 75 to 80 per cent. of the metallic iron, including the six pounds of sheet-iron canister. An estimate for metal transferred in the canisters, while hot, to the open-hearth furnace, sufficient for one ton of steel stock, exclusive of wear and tear and general expenses, foots up to $17.23."

ANOTHER DIRECT PROCESS,

The invention of Dr. Siemens, has also been spoken of during the year. The inventor is still engaged in experimenting, with the view of further improvements, and hence no results are available. So far as we can learn, the process consists in melting cast-iron and iron ore together in a furnace, by which the carbon of the former combines with the oxygen of the latter, and leaves the resulting mass free from carbon. From time to time samples of the metal are drawn from the furnace and the progress of the transformation observed. When all the carbon has disappeared, a requisite quantity of spiegel-eisen is added, and the mass thereby converted, as in the Bessemer process, into steel.

COMPARISON OF A COAL-FURNACE AND A SIEMENS GAS-FURNACE IN THE MANUFACTURE OF PLATE-GLASS.

The following comparative statement, furnished by one of our leading Western establishments, affords a striking evidence of the superiority of the gas-furnace in this special industry:

The coal-furnace contained twelve pots, each having a capacity of 800 pounds—giving, therefore, 9600 pounds to a melt, averaging twelve hours to a heat, and consuming twelve tons of coal per twenty-four hours. The flame intensity was unequal, and in consequence of this non-uniformity of heating, the breakage of pots was considerable. The quality of glass made was variable; and from the impure character of the flame, the pots needed considerable skimming.

The Siemens gas-furnace that replaced the above contained sixteen pots, each having a capacity of 1000 pounds—giving, therefore, 16,000 pounds to a melt, averaging twelve hours to a heat, and consuming four and a half tons of coal per twenty-four hours. The quality of product was uniformly excellent. If required, eight melts per week can be made. The uniformity of the heating and the purity of the flame effected a notable saving of pots (as much as 50 per cent. over the old furnace). But trifling skimming was required, and the yield of product per melt is fully 30 per cent. greater than in the coal-furnace.

The gas-furnace supplying the above facts was started in August, 1877, and at the time of writing shows but little wear; and during September but four pots out of the sixteen were broken.

TELEGRAPHY.

The report of the President of the Western Union Telegraph Company for the year ending June 30, 1877, showed that the company operated 76,955 miles of line and 194,323 miles of wire—being an increase of 3423 miles of line and 10,491 miles of wire as compared with the preceding year. These data do not, of course, include the lines operated by rival companies, and by numerous railroads and other corporations and business firms throughout the country, and which would very largely swell the figures named above. The arrangement made last year between the Western Union Company and the Atlantic and Pacific Telegraph Company, by which the gross receipts of the combined companies shall be pooled and divided upon a certain basis agreëd upon, was one of the notable commercial events of the past year, the substantial business effects of which consolidation will be likely to accrue to the companies more palpably than to the public. The quadruplex system has been largely introduced in this country during the year, and is rapidly growing in favor in England.

The agitation of the question of underground lines in cities, which was more earnest than ever before, does not appear to have borne any substantial fruit during the past year in this country. Abroad, however, the German Government has been steadily perfecting and completing an extensive network of subterranean lines to connect the chief

cities of the empire. The successful completion of the line laid down between Berlin and Halle (a distance of about one hundred and five miles), which went into operation towards the close of 1876, appears to have given great impetus to the system in that country. The following lines have been decided upon, and at the time of this writing several have been either completed or have been well advanced, viz.: Halle-Leipsic, Halle-Cassel-Frankfort-Mayence, Berlin-Hamburg, and Hamburg-Kiel. The practical working of these lines will be watched with very general interest, since they are expected to definitely decide the question of the practicability of the underground system, not simply for cities, where its utility has long since been demonstrated by general use abroad, but as a substitute for the aerial system in general. Up to the present time the Berlin-Halle cable, the only branch of which any report has appeared, has given entire satisfaction.

THE ARTICULATING TELEPHONE,

Although first presented to the world in crude form at the Centennial Exhibition in 1876, was so greatly improved and simplified during the past year that we may date its introduction as a practical telegraphic apparatus from the 4th of May, 1877, when Professor Graham Bell exhibited to an audience in the Boston Music Hall a speaking telephone in operation between that place and Providence, forty-three miles distant. The apparatus, since this first public demonstration, from its great novelty and possible utility, attracted almost universal attention, and was described and exhibited before scientific societies and public lectures with great *éclat;* and at the time of present writing has been largely introduced both at home and abroad as a means of communication in a great variety of situations. The longest line in actual operation at the present is that between Boston and New York, a distance of two hundred and fifty miles. The first practical application of the instrument was made by the Board of Water Commissioners of Cambridge, Mass., between the central office and the water-works under their control. Up to the close of the year, it is safe to say that several thousand of these instruments are in practical use in the United States, in very various situations; and their

use promises to become almost universal. Experiment has shown that the Bell telephone can transmit articulate speech through a resistance equal to five hundred and fifty miles of telegraph wire. In practice, however, it has not been found possible to speak through this distance, partly from loss of current by interference of induced currents from other wires, and partly on account of loss by leakage. It is impossible to say to what degree of perfection the instrument may not be brought by subsequent improvements.

THE PHONOGRAPH.

An apparatus which shall make a permanent graphical record of spoken words or musical sounds, and by means of which we may be able, at any future time, to reproduce, in audible form, the same sounds it has recorded, and with all the peculiarities of pronunciation and inflection—in other words, a veritable talking-machine—has been successfully realized in practice by Mr. T. A. Edison, who has styled it the phonograph. Although as yet imperfect, it is nevertheless sufficiently practical to prove beyond doubt the practicability of a talking-machine that will store up sounds indefinitely and reproduce them at pleasure. To venture an opinion of its possible utility at this time would be premature.

ELECTRIC LIGHTING.

During the past year considerable attention has been directed towards the subject of electric lighting. The interest developed was mainly due to certain inventions of M. Jablochkoff, who has succeeded in producing a very much simplified form of lamp, by means of which, without the necessity of employing clock-work or other mechanical artifices, it is rendered possible to work a number of lights independently on the same circuit, so that an accident to or the extinction of one lamp will not affect the others.

The device above alluded to, known popularly as "The Jablochkoff Electric Candle," consists essentially of two rods of gas carbon, held side by side by a holder of asbestos, but kept slightly apart by the interposition of a slender rod of some insulating material (kaolin, glass, etc.). The carbons are held in tubes of copper, and copper wires in connection with these conduct the current from the dynamo-electric

machine employed to supply the power. The heat of the electric arc is sufficient to vaporize the insulating material employed between the carbons, as these are consumed, and thus their relative distances are preserved. The alternation of the current provides for any unequal consumption of the carbons. The candle may be used in any position. It admits of being lighted at a distance by placing previously a piece of pencil-lead between the carbons, which allows the current to pass at first, but gradually consumes, after which the brilliant arc appears. The gradual fusion, also, of the insulating material increases the length and intensity of the light produced. It has been suggested, likewise, that the candle might be employed for transmitting signals by flashes, inasmuch as it may be repeatedly relighted after being extinguished by the breaking of the circuit, provided the interval be not too long. This invention has undoubtedly carried us a decided step forward towards proving the entire practicability of the electric light for general lighting purposes. The cost of operating is said to be considerably lower than that of coal-gas, experiments at the West India Docks, London, having afforded the ratio of 30 to 100, showing a saving, estimated on an equivalent quantity of light supplied by both methods, of 70 per cent. in favor of the electric light.

We may also mention, in this connection, the fact that an electro-magnetic machine designed by Loutin, and by which a number of independent currents of different strengths are generated and distributed to separate circuits to feed a separate light in each, has been tried with much success in France.

In connection with light-house illumination, the comparative trials of the magneto-electric machines of Siemens, Gramme, and Holmes at the South Foreland Light-house, made under the direction of Professor Tyndall, are worthy of notice. These trials appear to have established the superiority of the Siemens machine.

UTILIZATION OF BLAST-FURNACE SLAG.

It is worthy of remark that during the past year the subject of turning this waste product of the iron-manufacture to good account has attracted a considerable share of atten-

tion in view of the revival of certain suggestions concerning its possible utilization, and the success of certain processes in actual use. The following are some of the suggested uses of this material: It has been proposed to cast it, in imitation of stone, directly into paving and building blocks, slabs, and pipes; or to color it before casting for making it into decorative tiles and other shapes to imitate marbles and other highly prized decorative stones; to pulverize it for use as cement, with lime; to granulate it, or pulverize it as a material for building-sand, or as the basis of a roofing-material; to produce therefrom the commoner varieties of glass; and to blow it by means of a steam-jet into the condition of a fine wool, to serve the general purposes of a non-conductor of heat. Some of these suggestions have been tried and abandoned; others, however, have been found to give profitable results, and are successfully practised. This is notably the case in Germany at the Georg-Marien Hütte at Osnabrück, where large quantities of slag are granulated and made (with mortar) into excellent and very popular building-blocks or bricks. The yearly production at this furnace alone is not less than 7,000,000 at the present time, and its total production up to the close of 1876 had reached 29,-500,000.

Of still greater possible utility is the suggestion made by Mr. Bashley Britton before the British Iron and Steel Institute to utilize this waste product for producing the cheaper varieties of glass. Mr. Britton contends that while it is unfitted for the production of perfectly white glass—from the amount of iron which it contains—yet for all glass in which a tinge of color is either desired or is not detrimental—and this includes a large percentage of all the glass that is made—the slag will be found quite well adapted, the percentage of iron which it contains being actually beneficial, since, being capable of replacing other fluxes, it will lessen the amount of alkali that would otherwise be required. Mr. Britton, in his very instructive paper, goes into much detail to show how glass-making can be profitably introduced in many locations in connection with iron furnaces. His plan is at present being tried, we understand, in one or more localities in England, and the practical results will be looked for with great interest.

More curious, and not less useful, is the production of mineral wool above alluded to. This material, known also under the names of slag-wool and silicate cotton, is said to be made extensively at the Georg-Marien Hütte at Osnabrück and at Krupp's furnaces, in Germany, and to be largely used in England as a non-conductor upon steam-pipes, boilers, etc. This manufacture was made the subject of a patent in this country in 1871 by Mr. John Player; and though the material then produced was crude in comparison to what is now produced, its non-conducting qualities gained for it a favorable report from a committee of the Franklin Institute by whom it was examined in that year. Since then, however, Mr. Alexander Elbers has greatly improved the process of manufacture and the products; and we are assured of the somewhat surprising fact that since 1876 no less than 1,000,000 pounds of the material have been made at the Clove Furnace, Greenwood.

COLD-PUNCHED *vs.* HOT-PRESSED NUTS.

The method of producing nuts by a process of cold-punching, which was alluded to in an earlier volume of the *Record* as a mechanical feat of extraordinary character, has achieved a signal triumph during the past year, by reason of the results of a series of competitive tests of nuts made by this and by the usual method of hot-pressing, which results showed most decidedly the superiority of the new process over the old.

The tests in question were made by Professor R. H. Thurston at the mechanical laboratory of the Stevens Institute of Technology; and while we have not the space to enter into the details of the experiments, it may suffice to say that the tests were made both by stripping stress and bursting stress, and were so elaborately and carefully conducted, upon a programme mutually agreed upon by the representatives of the rival systems, as to be apparently conclusive.

The results of the trial, according to Professor Thurston, may be taken as conclusive in proving: "First, that the cold-punched nuts possessed a much greater average strength, combined with greater rigidity, and slightly greater uniformity than were exhibited by the hot-pressed nuts; and that the superiority was most strongly manifested in the

trials by stripping stress. Second, that the cold-punched nuts exhibited a strength never attained by the hot-pressed nuts, but that such variations in the strength of both styles occurred as to have caused the hot-pressed nuts to equal, and occasionally to excel, in strength the weakest specimens of cold-punched nuts."

IRIDESCENT GLASS.

Some interesting results of experiments upon the artificial production of the iridescent glass of the ancients, so highly prized by antiquarians, have been reported by two French chemists, MM. Frémy and Clémandot. These investigators ascertained by observation that glass, when subjected to conditions which determine its gradual decomposition, becomes covered with slender laminæ which present the remarkable phenomenon of irisation. They have succeeded, according to account, in producing this irisation on glass so that it shall present the peculiar appearance of mother-of-pearl, by submitting it, under the influence of heat and pressure, to the action of water containing 15 per cent. of hydrochloric acid. Only certain kinds of glass, however, are suited for this treatment, and the conditions of composition as well as those of annealing affect the result.

It is not improbable that this observation may be the initial step to the restoration of "a lost art" or the establishment of a new one. The products of this new manufacture —ornamental vases, cups, bowls, etc.—which appear to have already been placed upon the market abroad in considerable quantity, though very beautiful, are said to be as yet much inferior to the Assyrian or Egyptian iridescent glass, in the production of which time is held to be an important factor.

MISCELLANEOUS.

Some attention was attracted among iron-workers by the announcement of the discovery, by Professor Barff, of a method by which iron may be effectually prevented from rusting, and, "however much exposed to the weather or corrosive vapors or liquids, rendered practically indestructible and everlasting." The process in question consists, substantially, in subjecting the iron to the action of superheated steam, whereby it acquires a thin but firmly adherent coating of magnetic

oxide, which, it is affirmed, by its great indifference to atmospheric and chemical agencies, effectually protects the underlying metal from further change from these causes. Dr. Percy has confirmed the importance of this method; and, in a paper read before the last meeting of the British Iron and Steel Institute, laid down the general proposition that the most effectual mode of protecting metals from atmospheric action is to impart to them "a coating of their own oxides respectively." This very rational generalization he demonstrated to be correct in the cases of iron, copper, and lead.

A new process of electroplating, which may become of great utility, has been described in *Silliman's Journal*, by Professor A. W. Wright, of Yale College. It is based upon the fact that the various metals may be volatilized by the electrical current. He provides a hollow vessel, from which the air has been partly exhausted, and arranges therein at proper distances apart the poles of an induction coil—the article to be electroplated being suspended between the poles. The negative pole carries a small piece of the metal that is to be deposited, and a battery of three to six or any number of cells is employed as may be necessary. The metal volatilized by the spark is condensed on the cold surface (glass, etc.), forming a firmly adherent, brilliant, and uniform coating. The invention has already been successfully applied in practice, and promises to become valuable.

The prize offered by the Prussian Minister of Commerce and Industry for a method of preparing plaster casts so that they may be washed when necessary without impairing their sharpness, was lately awarded to Dr. Reissig, of Darmstadt, who offered the following suggestions: 1st, to convert the sulphate of lime into the sulphate of baryta by washing the surface with strong baryta water; and, 2d, to convert the sulphate of lime into silicate by the application of silicate of potassa. The object to be attained is to form a surface which shall not dissolve in water and shall prevent dust from entering the pores. The above methods of treatment render plaster casts indifferent to the action of hot water and soap, but leaves them porous and capable of retaining dust, so that an additional treatment is necessary to remedy this defect. This consists in the application of an

alcoholic soap solution, which, on evaporating, leaves a layer of soap on the surface effectually stopping up the pores.

From the official decree of the Superior Council relative to the matter of awards at the coming Exposition in Paris, it appears that the sum of 1,500,000 francs has been appropriated for that purpose, which sum will be awarded and distributed by a jury composed of three hundred Frenchmen and three hundred and fifty foreigners. The foreign jurors are selected by their respective governments, and those of France by the Superior Council. This international jury is to complete its work between June 1 and September 1, 1878, inclusive. The distribution of awards is fixed for September 10, 1878. The rules and regulations for the government of the jury are the same as those of the Centennial Exhibition of 1876.

INDUSTRIAL STATISTICS.

By WILLIAM H. WAHL, Ph.D.,
PHILADELPHIA, PA.

The following compilation from the carefully collected statistics of the American iron trade for 1876 is made as nearly as possible uniform with that published in our last year's *Record*, to render comparison easy:

PRODUCTION OF PIG-IRON IN 1876.

The secretary of the American Iron and Steel Association reports that the production of pig-iron in the United States in 1876 was 2,093,236 net tons (a very slight variation from his estimate as furnished to our last), against 2,266,581 tons in 1875, 2,689,413 tons in 1874, 2,868,273 tons in 1873, and 2,854,558 tons in 1872. A comparison of these figures shows a decrease in 1876, as compared with 1875, of 173,345 tons, or about 8 per cent. Commenting upon his figures, the secretary says: "Since 1873 — the year of greatest production—each year has shown a decrease as compared with the preceding years, the percentage of decrease being as follows: 1874, 6 per cent.; 1875, 15 per cent.; 1876, 8 per cent. From 1873 to 1876 the decrease has been 775,042 tons, or 27 per cent. This is a very great shrinkage, and indicates, with concurrent low prices, a very great depression in the pig-iron industry of the country. If the rate of decrease which marked the period from 1873 to 1876 were to be continued, the production of pig-iron in the United States would entirely cease in 1884—less than eight years from the present time; and our furnace-stacks would only be useful as observatories for the study of astronomy."

The secretary does not admit, however, that things are so bad as they at first appear, and points to the marked diminution in the percentage of decrease in 1876 as compared with that of 1875, and to the decided diminution of stocks on hand and unsold at the close of 1876 (106,110 tons less than

at the close of 1875), as strong symptoms of an early increase in the manufacture of American pig-iron. This judgment is confirmed by the following statement, politely furnished by the secretary to the writer, giving his estimate of the production of pig-iron during the year 1877, to wit: "This year [1877] we will make a little more pig-iron than last year—probably 2,200,000 net tons. The other items of production will stand about the same in 1877 as in 1876."

Of the total production of 1876, 794,578 tons were smelted with anthracite coal, 990,009 tons with bituminous coal and coke, and 308,649 tons with charcoal. The whole number of completed furnaces in the country at the close of 1876 was 714 (against 713 in the preceding year). Ten new furnaces were built in 1876, and 9 old ones were abandoned. Of this total of 714 furnaces at the close of 1876, 236 were in blast and 478 out of blast. Of the product of 1876, Pennsylvania made 48.2 per cent. and Ohio 19.2 per cent., both increasing their percentage of production as compared with the preceding year. The other iron-making states, with few exceptions, decreased their production as compared with 1875.

CONDITION OF BLAST-FURNACES OCTOBER 1, 1877.

For comparison with a similar statement given in last year's *Record*, we append herewith a summary of a detailed statement published by the *Iron Age* of New York, showing the condition of the blast-furnaces of the United States on October 1, 1877:

Number of charcoal-furnaces in blast (weekly capacity 7887 tons)	89
Number of charcoal-furnaces out of blast (weekly capacity 12,957 tons)	176
Number of anthracite-furnaces in blast (weekly capacity 17,067 tons)	86
Number of anthracite-furnaces out of blast (weekly capacity 25,268 tons)	140
Number of bituminous or coke furnaces in blast (weekly capacity 19,670 tons)	77
Number of bituminous or coke furnaces out of blast (weekly capacity 29,780 tons)	136
Total furnaces in blast, October 1, 1877	252
Total furnaces out of blast, October 1, 1877	452
Weekly capacity of furnaces in blast (tons)	44,624
Weekly capacity of furnaces out of blast (tons)	67,995

A comparison of these figures with those of the preceding

year indicates that a larger percentage of charcoal and anthracite furnaces were in blast in 1877 than in 1876; while with bituminous furnaces there has been no change.

THE COMPARATIVE PRODUCT OF PIG-IRON BY STATES,

For a series of years, is shown in the accompanying table, based upon the statistics collected by the association from manufacturers, viz.:

STATES.	Whole Number Completed Furnaces, December 31.				Condition of Furnaces on Dec. 31, 1876.		Make of Pig-iron in net tons. (Tons of 2000 pounds.)			
	1873	1874	1875	1876	In.	Out.	1873.	1874.	1875.	1876.
Maine	1	1	1	1	1	...	780	1,661	2,046	3,002
Vermont	2	2	2	2	...	2	3,100	3,450	2,400	550
Massachusetts	6	6	6	6	1	5	21,136	27,991	21,255	5,040
Connecticut	10	10	10	10	4	6	26,977	14,518	10,880	10,160
New York	53	58	57	57	23	34	296,818	326,721	266,431	181,620
New Jersey	16	17	18	18	4	14	102,341	90,150	64,069	25,349
Pennsylvania	262	266	278	279	113	166	1,389,573	1,213,133	960,884	1,009,613
Maryland	22	23	24	24	5	19	55,986	54,556	38,741	19,876
Virginia	35	38	34	33	6	27	26,475	29,451	29,985	13,046
North Carolina	8	8	8	8	...	8	1,432	1,340	800	400
Georgia	8	10	12	11	2	9	7,501	9,786	16,508	10,518
Alabama	11	14	14	13	5	8	22,283	32,863	25,108	24,732
Texas	1	1	1	1	...	1	280	1,012	....	426
West Virginia	6	9	12	12	1	11	23,056	30,134	25,277	41,165
Kentucky	25	27	23	23	4	19	69,889	61,227	48,339	34,686
Tennessee	20	22	22	24	5	19	43,134	48,770	28,311	24,585
Ohio	88	93	100	100	38	62	406,029	425,001	415,893	403,277
Indiana	8	8	9	9	3	6	32,486	13,732	22,081	14,547
Illinois	10	10	12	12	3	9	55,796	37,946	49,762	54,168
Michigan	33	34	34	34	7	27	123,506	136,662	114,805	95,177
Wisconsin	13	14	14	14	5	9	74,148	50,792	62,139	51,261
Missouri	18	19	19	19	6	13	85,552	75,817	59,717	68,223
Oregon	1	1	1	1	...	1	....	2,500	1,000	1,750
Utah	...	1	1	2	...	2	....	200	150	65
Minnesota	...	1	1	1	...	1	....	....	....	....
Total	657	693	713	714	236	478	2,868,278	2,689,413	2,266,581	2,093,236

RECAPITULATION.

KINDS OF PIG-IRON.	Whole Number Completed Furnaces, December 31.				Condition of Furnaces on Dec. 31, 1876.		Make of Pig-iron in net tons. (Tons of 2000 pounds.)			
	1873	1874	1875	1876	In.	Out.	1873.	1874.	1875.	1876.
Anthracite	207	217	225	228	85	143	1,312,754	1,202,144	908,046	794,578
Charcoal	279	295	281	280	73	207	577,620	576,557	410,990	308,649
Bituminous coal and coke	171	181	207	206	78	128	977,904	910,712	947,545	990,009
Total	657	693	713	714	236	478	2,868,278	2,689,413	2,266,581	2,093,236

PRODUCTION OF ROLLED IRON IN 1876.

The association statistics place the total production of all kinds of rolled iron in the United States in 1876 at 1,921,730 net tons, as compared with 1,890,379 tons in 1875, 1,839,560 tons in 1874, and 1,966,445 tons in 1873. The production in this branch of our iron manufacture, it will be observed, has maintained a remarkable uniformity for several years, indicating that the rolling-mills of the country have been actively employed.

RAIL PRODUCTION IN 1876.

There were rolled in 1876 879,629 net tons of iron and steel rails of all sizes, against 792,512 tons rolled in 1875—showing an increase of 87,117 tons, or 11 per cent., upon the make of 1875. Of this total production for 1876 there were 412,461 tons of Bessemer rails and 467,168 tons of iron rails, against 290,863 tons Bessemer and 501,649 tons iron rails in 1875. These figures show not only that the Bessemer industry is rapidly expanding, but that the Bessemer rail production has practically overtaken that of iron. Distributed throughout twenty-five states and Wyoming Territory, there were, at the close of 1876, 338 rolling-mills, with 4488 puddling-furnaces. Of this number of mills 260 were in operation during the whole or part of the year. The capacity of the mills of the country is at least double the production of 1876.

THE BESSEMER-STEEL INDUSTRY.

In 1876 there were 11 Bessemer steel establishments in operation in the United States. These were located as follows: 5 in Pennsylvania, 3 in Illinois, and one each in New York, Ohio, and Missouri. The number of converters in use in 1876 was 22. The details of production appear from the following table, viz.:

Items.	1874.	1875.	1876.
	Net Tons.	Net Tons.	Net Tons.
Pig-iron and spiegel converted	204,352	395,956	539,474
Ingots produced	191,933	375,517	525,996
Rails produced	144,944	290,863	412,461

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The Bessemer-steel industry consumed during 1876 one fourth of the pig-iron product of that year; and the proportions to which it has attained entitle it to rank as a leading branch of the iron industry of the country. The use of Bessemer metal as a substitute for wrought iron and other kinds of steel is steadily increasing.

The accompanying table, showing the production of Bessemer rails for a series of years, completes our annual review of this industry as far as January, 1877, viz.:

Years.	Net Tons.	Years.	Net Tons.
1867	2,550	1872	94,070
1868	7,225	1873	129,015
1869	9,650	1874	144,944
1870	34,000	1875	290,863
1871	38,250	1876	412,461

Showing a total production since 1867 of 1,163,028 net tons.

STEEL PRODUCTION OTHER THAN BESSEMER.

From the elaborate statistics of Mr. Swank we are enabled to glean that during the year 1876 the production of crucible, puddled, blister, and open-hearth steel, in the forty-seven establishments at work in the country, was 71,178 net tons, against 61,058 tons in 1875 and 49,681 tons in 1874. Of the product of 1876, 39,382 tons were crucible steel, 21,490 were open-hearth, and 10,309 puddled and blister steel. The following table shows the production by states and districts:

Districts and States making Steel in 1876.	Crucible Steel.	Puddled, Open-hearth, and Blister Steel.	Total.
	Net Tons.	Net Tons.	Net Tons.
New England............	1,098	6,085	7,183
New York...............	2,300	139	2,439
New Jersey.............	6,806	652	7,458
Pennsylvania...........	28,217	15,148	43,365
Ohio...................	700	9,558	10,258
Maryland and Tennessee..	261	214	475
Total..................	39,382	31,796	71,178

PRODUCTION OF IRON AND STEEL BY THE OPEN-HEARTH PROCESS (on the authority of Messrs. Richmond and Potts).

Steel or homogeneous iron made by the Siemens open-hearth furnaces during the year 1876 (net tons)...................... 24,069

Total number of Siemens's furnaces in the iron and steel works of the United States to date.. 141

For heating iron or steel, capacity of each furnace from 20 to 60 tons per 24 hours	86 furnaces.
For melting steel on the open hearth	21 "
For melting steel in crucibles (each furnace of 24 or 30 pots capacity)	34 "

The total capacity of the Siemens crucible steel-melting furnaces is 828 pots per heat, representing an annual productive capacity of 33,000 tons in 250 working days. The following are new furnaces erected during the year 1877:

Open-hearth	4 furnaces.
Crucible steel-melting	2 "
Heating, iron or steel	13 "

Besides the above, the furnace, during the year 1877, has been introduced with excellent results for the manufacture of glass and the smelting of zinc ores.

We add to the above the following estimate of production for the year 1877 (furnished by Messrs. Richmond and Potts):

By Siemens's crucible steel-melting furnaces (net tons)	31,920
" " open-hearth furnaces (net tons)	42,168

THE PRODUCT OF THE FORGES AND BLOOMERIES

For the year 1876 is placed at 44,628 net tons, as compared with 49,243 tons during 1875.

GENERAL ANALYSIS OF TOTAL IRON AND STEEL PRODUCTION.

The following table carries the figures presented in our last *Annual Record* to January 1, 1877. It is an analytical statement of production, in net tons, of the several branches of iron and steel industries, and affords a comprehensive view of the condition of the several branches of the iron trade for a series of years, as derived from the statistical reports of the American Iron and Steel Association, and which may therefore be regarded as approximating as nearly to the truth as it is possible to attain in a review of allied industries of such magnitude.

The most noticeable feature of this table, it will be observed, is the enormous increase of the figures referring to

the Bessemer steel industry, and the considerable increase, though on a scale of lesser magnitude, of the figures of production of open-hearth steel.

As before remarked, the corresponding figures for 1877 must be omitted, as the very rough approximation that might be ventured would have but little value.

Products.	1873.	1874.	1875.	1876.
	Net Tons.	Net Tons.	Net Tons.	Net Tons.
Pig-iron	2,868,278	2,689,413	2,266,581	2,093,236
All-rolled iron, including nails and rails	1,966,445	1,839,560	1,890,379	1,921,730
All-rolled iron, including nails and excluding rails	1,076,368	1,110,147	1,097,867	1,042,101
Rails of all kinds	890,077	729,413	792,512	879,629
Bessemer steel rails	129,015	144,944	290,863	412,461
Iron and all other rails	761,062	584,469	501,649	467,168
Street rails, included in iron rails	9,430	6,739	16,340	13,086
Kegs of cut nails and spikes	4,024,704	4,912,180	4,726,881	4,157,814
Crucible cast steel	32,786	34,128	39,401	39,382
Open-hearth steel	3,500	7,000	9,050	21,490
All other steel, excluding Bessemer	13,714	6,353	12,607	10,306
Total Bessemer steel	170,652	191,933	375,517	525,996
Blooms from ore and pig-iron	62,564	61,070	49,243	44,628

THE IRON TRADE OF THE UNITED STATES IN 1877.

From the most recent statements that have appeared in the *Bulletin* of the American Iron and Steel Association, it appears that while the year 1877 has proved to be the most disastrous of any since the panic, the demand for our iron and steel products was greater than during the year 1876. The secretary estimates that the production of pig-iron during 1877 exceeded that of 1876 by about ten per cent., and thinks that it will approximate to that of 1875, which was 2,266,581 tons. The production of Bessemer steel during 1877, he affirms, will fully equal the product of 1876 (525,996 net tons ingots, and 412,461 tons rails). The production of steel rails in 1877, he believes, will not vary greatly from 450,000 net tons. In iron rails, however, he anticipates that the year 1877 will show some falling-off. The secretary notices that the imports and exports of iron and steel in 1877

will correspond very closely to the figures of 1876, and that they will show no change in quantities and values worthy of special mention.

COAL TRADE OF 1877.

The *Engineering and Mining Journal* estimates the production of anthracite in 1877 to have been about twenty-one million tons, or about two million tons more than in 1876. The production of bituminous and post-carboniferous coals is estimated by the same authority to have amounted to more than twenty-eight million tons, gross—making an aggregate coal production for the United States of nearly fifty millions of gross tons, or, say fifty and three quarter million metric (net) tons. The estimated production of anthracite by regions is given as follows:

	Gross Tons.		Gross Tons.
Wyoming region........	8,300,000	Schuylkill region........	8,600,000
Lehigh "	4,400,000	Loyalsock "	23,000
Total...			21,323,000

The exports of coal for the fiscal year ending June 30, 1877, were 418,791 tons anthracite and 321,665 tons bituminous.

PRODUCTION OF PRECIOUS METALS IN 1877.

Although somewhat too early for the presentation of precise figures of production of the precious metals for the past year, we are in possession of official statements from two sources which certainly approximate very closely to accuracy. The estimate of Wells, Fargo, and Co. of the production of the precious metals in the states and territories west of the Missouri River, including British Columbia and the west coast of Mexico, during 1877, shows an aggregate yield of \$98,500,000—an increase of \$7,500,000 over that of 1876. The *Engineering and Mining Journal* gives a more detailed estimate, which corresponds very closely with the foregoing, viz.:

Arizona	\$1,500,000	Nevada	\$50,000,000
California	20,000,000	New Mexico...........	500,000
Colorado	7,500,000	Oregon and Washington	1,000,000
Dakota..................	1,500,000	Utah	4,500,000
Idaho	3,500,000	Wyoming.............	250,000
Montana................	5,000,000	Total	\$95,250,000

This amount, divided among the several metals produced, gives the following result:

Gold	$45,300,000	Lead	$2,900,000
Silver	46,075,000	Copper	97,5000
Total			$95,250,000

The totals here given show an advance of about 8 per cent. on the figures of last year.

NECROLOGY.

Anthony, J. G. Curator of the department of Conchology in the Museum of Comparative Zoology, Cambridge. Born at Providence in May, 1804. Died in his seventy-third year.

Apjohn, Richard. A young chemist of great promise, and author of a number of essays and articles on chemical subjects. In 1874 elected Prælector of Chemistry in Caius College, Cambridge. Died September 12th.

Bain, Alexander. An eminent electrician, and inventor of the electro-chemical telegraph and other devices in the application of electricity. Died at Glasgow, January 2d, at the age of sixty-six.

Barbot-de-Marny, Professor N. P. A Russian geologist. Died in May, at the age of forty-five.

Barth, Baron. While engaged in making a geological and botanical survey in Africa for the Portuguese Government, committed suicide at Loanda, December 7th, 1876, under an attack of fever.

Bary, Dr. Erwin von. A zealous African explorer, especially of the interior of the Sahara. Died October 2d, from the effects of exposure and privation.

Belcher, Sir Edward. A well-known arctic explorer and hydrographer. Died in his seventy-ninth year.

Bellynek, The Abbé. A distinguished Belgian botanist. Died at Nemours, January 14th, at the age of sixty-seven.

Bicknell, Edward. A well-known microscopist and writer on microscopical subjects; especially skilled in the preparation of injected objects. Died at Lynn, Mass., March 19th, at the age of forty-seven.

Bourgean, E. A well-known botanical collector in Mexico during French occupation, and in other parts of North America. Died in France.

Bowerbank, J. Scott. Author of many works on the lower organisms, especially the sponges, and one of the founders of the Royal Microscopical Society and the Paleontographical Society. Died at Hastings, March 8th, in the eightieth year of his age.

Braun, Dr. Alexander. A distinguished botanist. Born May 16th, 1805, at Ratisbon. Died March 29th at Berlin, in the seventy-second year of his age.

Bremiker, Dr. C. An eminent astronomer. Died March 26th, in the seventy-fourth year of his age.

Brooks, Lewis. A munificent friend of learning by his contributions to the educational facilities of various establishments. Born at Milford, Conn., in 1793. Died at Rochester, N. Y., in the eighty-fourth year of his age.

Carpenter, Dr. P. P. Born in 1807. Died at Montreal, May 24th. A distinguished conchologist; especially devoted to the study of the shells of the Pacific; the author of numerous papers, based principally on the collection of the British Museum and of the National Museum at Washington; those among the more important being a work on the shells of Mazatlan, lists of the shells of the west coast of America, and a monograph (nearly completed) on the shells of the Chiton group.

Cazin, Professor. A member of the French Transit of Venus Expedition to the island of St. Paul, contracting there the disease of which he died in Paris.

Cerf, Mademoiselle Henrietta. Author of various articles on the botany of Kent and Belgium. Died at Brussels, October 22d.

Cheyne, C. H. Author of a work on the planetary theory. Died on the 1st of January, at the age of thirty-eight.

Compiègne, Marquis de. A well-known African explorer. Killed in a duel at Cairo, on the 22d of February, at the age of thirty.

Conrad, Timothy Abbott. An accomplished paleontologist, and author of many valuable papers on recent and fossil shells. Born in 1803.

Credner, Professor Heinrich. A mining engineer. Author of a work on the geology of Thuringia and the Harz, etc. Born in 1809. Died September 28th.

Cross, George. Member of the Chester Natural History Society. An efficient teacher in the British Science and Art Department. Died April 16th, at the age of forty.

Danby, Professor John. Author of a Botany of the Southern United States. Died in August, at the age of seventy-three.

Davis, Captain J. E. Well known from his connection with the hydrographic department of the Admiralty, and as master of the *Terror* on the Arctic Exploring Expedition under Sir James Ross. Author of a series of articles upon the hydrographic and other operations of the *Challenger*. Died in January, at the age of sixty-one.

Davis, Rear-Admiral Charles Henry. An accomplished American naval officer, and well known for his scientific attainments. Author of a paper on "The Law of the Deposit of the Flood Tides" and other essays; for many years charged with the publication of the *Nautical Almanac;* editor of the American edition of the "Theoria Motus" of Gauss; at one time Chief of the Bureau of Navigation, and also Superintendent of the Naval Observatory.

De Notaris, Giuseppe. Born at Milan, May 5th, 1805. Died at Rome, January 22d. Professor of Botany at Genoa and at Rome; especially interested in cryptogamic plants, particularly the mosses and fungi.

Deshaies, Alfred. Connected with the chemical department of the College of France. Died suddenly, as supposed, from the effect of some chemical agent, whose toxic properties he was investigating.

Deville, Charles Sainte-Claire. An eminent French scientist; an explorer of the Antilles and the volcanic islands of Africa, and a noted collector of rocks and fossils. For a time he occupied the chair of geology in the College of France. Died October 10th, from the effects of the bite of a dog.

Drummond, James. Died in the early part of January.

Dumortier, Eugene. Author of a work on the "Jurassic Deposits of the Basin of the Rhine." Died at Lyons in August, 1876, aged sixty-six.

Dunn, Mr. An English author of several works on physiological psychology and medical psychology. Died in November.

Eichwald, Professor von. A Russian geologist. Author of "Lethæa Rossica." Born in 1795 at Mitau.

Erman, Professor George A. An eminent German geographer and explorer. Died in Berlin, July 12th, in the seventy-second year of his age.

Foetterle, Dr. Franz. Vice-Director of the Geological Survey of Austria. Born in 1849.

Fox, Robert Were. Author of valuable papers on geology and mining. Died at Falmouth, England, in his eighty-fourth year.

Frantzius, Dr. Alexander von. Well known in connection with his scientific exploration of Costa Rica, in which he gathered valuable natural-history collections. Author of many memoirs on the natural history, geology, and medical history of the country; a correspondent of the Smithsonian Institution at Washington. Died at Freiburg, in Baden, July 18th.

Gassiot, J. P. Distinguished for his investigations in reference to electricity and magnetism. Founder of the Royal Scientific Relief Fund. Died August 15th, at the age of over eighty years.

Gossage, William. Discoverer of some important practical applications in chemical technology. Died April 9th.

Griffin, John J. Known best in the department of chemistry and mineralogy. Editor of the *Encyclopædia Metropolitana.* Died in June, at the age of seventy-five.

Heathcote, Commander J. A., R. N. Author of works on the meteorology and hydrography of India. Died January 3d.

Heis, Professor Edward. Director of the observatory at Münster, and author of many important astronomical publications. Died from apoplexy, June 30th, in the seventy-first year of his age.

Heuglin, Theodor von. A distinguished naturalist and traveller, especially in Africa; author of numerous works, among them a monograph on the birds of Northern Africa. Died at Stuttgard, November 5th, at the age of fifty-two.

Hofmeister, Professor Wilhelm. Professor of Botany at Tübingen, and formerly in the University of Heidelberg; especially known from his publications in regard to the embryology and physiology of plants. Died at Tübingen, January 12th, at the age of fifty-two.

Jewett, Colonel E. A well-known American naturalist and collector. Died at Santa Barbara, Cal., May 18th, in the eighty-sixth year of his age. For a time Curator of the New York State Cabinet of Natural History.

Jones, John. Founder and Secretary of the Iron and Steel Institute of Great Britain. Best known by his writings on the geology of the South Staffordshire district. Died in England, June 6th, at the age of forty-two.

Keeler, Henry D. A well-known American botanist.

Kirtland, Dr. Jared P. Born at Walbridge, Conn., in November, 1793. The first student matriculated in the medical department of Yale College; Professor of the Theory and Practice of Medicine in the Ohio Medical College, also in the Western Reserve College; Zoologist to the Geological Survey of Ohio in 1848; characterized by great enthusiasm as a naturalist; described many new species of Western fishes; successful as a horticulturist, as an apiarian, and as a sericulturist. A member of most of the learned societies in the United States, including that of the National Academy of Sciences, and also of several in Europe.

Lawson, Dr. Henry. Editor of the *Monthly Microscopical Journal* and other scientific journals, and a well-known writer on medical subjects. Died in the latter part of October.

Lestidubois, Thémistocle. Formerly Professor of Botany at Lille, and an author of some note. Died in the summer, at the age of eighty.

Leverrier, Madam. Widow of the distinguished Professor Leverrier. Died November 1st, at the age of fifty-eight.

Littrow, Professor Karl von. Born at Kazan in 1811, and being the son of an eminent astronomer, he also became eminent in that science, and at the age of twenty was appointed assistant in the observatory at Vienna, and in 1842 became director of the same, retaining the position until his death. The author of numerous scientific papers.

Luro, Lieutenant E. Author of a work upon "The Country of Annam." Died in March, while serving as inspector of native affairs in Cochin China.

Milton, Viscount. An explorer in British North America, and author of the work entitled "The Northwest Passage by Land." Died in January, at the age of thirty-eight.

Mohr, Dr. A well-known author in connection with African explorations, while engaged in his researches on the West Coast, under the auspices of the German-African Society. Died at Malange, November 26th, 1876.

Morris, Professor O. W. Died August 9th, in the eightieth year of his age. For forty years connected with the New York Institution for the Deaf and Dumb; especially interested in meteorology, and an ardent botanist, being one of the earliest members of the Torrey Botanical Club.

Newton, Professor Henry. Best known in connection with the geological survey of the Black Hills region some years ago. Returning for the completion of his observations, he died of disease contracted in the field, August 5th.

Noad, Dr. H. M. A well-known author of important works on electricity and magnetism, and their applications in telegraphing. Died in July, in the sixty-third year of his age.

Nöggerath, Professor Jacob. Professor of Mineralogy in the University of Bonn. Died September 13th, at the age of ninety.

Norris, Thaddeus. A well-known angler, and author of "The American Angler's Book." Died in Philadelphia, in April, at the age of sixty-six.

Oppenheim, Professor. A German chemist, and Professor of Chemistry in the University of Münster, in Westphalia. Committed suicide in September, in consequence of the loss of his wife.

Orton, Professor James. Born in 1830. Died while crossing Lake Titicaca, in his forty-seventh year. Professor of Natural History in Vassar College, and Curator of the Giraud collection of birds; zealous and successful as an explorer and collector. The results of his labors were principally for the benefit of Vassar College.

Panceri, Professor. An Italian entomologist and physiologist.

Papadakis, Professor J. Rector of the University of Athens, and for a long time in charge of the department of mathematics and astronomy. Died in January.

Parlatore, Professor Filippo. An eminent Italian botanist, and Director of the Botanic Garden and of the Natural History Museum of Florence. Author of several monographs, published in De Candolle's *Prodromus*. Born August 8th, 1816. Died on the 9th of September, at Florence, aged sixty-seven.

Poggendorff, Professor J. C. Editor of Poggendorff's *Annalen*. Died at Berlin, in January, in his eighty-first year.

Reed, Dr. Stephen. An ardent geologist. Died July 12th, at Pittsfield, Mass., at the age of seventy-six.

Rovida, Professor. Professor of Special Pathology and Clinical Medicine at the University of Turin. Died at Milan.

Rygersma, Dr. V. A naturalist and physician, of St. Martin, West Indies. Added much to the knowledge of the conchology of the West Indies. Died March 4th.

Sager, Dr. Abram. An American anatomist and physiologist. Born in 1810. Died August 6th, at Ann Arbor, Mich., in the sixty-seventh year of his age.

Santini, Professor. Professor of Astronomy and Director of the Observatory in the University of Padua; his connection with the university dating from 1814. Noted for his investigations in relation to Biela's comet; an author of a valuable text-book of astronomy. Born in 1786.

Schythe, J. C. Attention first devoted to the geography of Greenland, upon which he published several memoirs; resided since 1850 in Chili, as Professor of Natural Sciences at Santiago. Served as governor of the Territory of Magellan from 1853 to 1865. Born Feb. 6, 1814. Died at Valparaiso, January 30th.

Smee, Alfred. A surgeon by profession, but devoting much time to industrial experiments, and a well-known electrician. Died January 11th, at the age of fifty-eight.

Smith, Mrs. Pleasance. Widow of Sir James Edward Smith, a distinguished botanist, who died in 1828. She followed him February 3d, 1877, at the age of one hundred and four years.

Spalding, Douglas A. A frequent contributor of articles in the department of mental science to *Nature.*

Strange, Lieutenant-Colonel A., F.R.S., etc. Inspector of Instruments to the Indian Government, and connected with the great Indian Trigonometric Survey.

Strong, Moses. Assistant Geologist of the Geological Survey of Wisconsin; a graduate of Yale College in 1867. Drowned August 18th, while engaged in a geological examination of the branches of the Chippewa River.

Stroudberg, Dr. President of the Swedish Academy of Sciences. Died at Stockholm, February 5th.

Swinhoe, Robert. Distinguished as a traveller and investigator of the natural history of China, Formosa, and other eastern countries. Born in Calcutta in 1836, where he also died in his forty-first year.

Talbot, W. H. Fox. Inventor of the Talbot-type process in photography, in 1840. Died September 17th, at the age of seventy-seven.

Tenney, Professor Sanborn. Professor of Natural History at Williams College; author of a valuable text-book of zoology. About to start in charge of an expedition, composed of students of Williams College, for the scientific exploration of a portion of the Rocky Mountains, he died of heart-disease, July 10th.

Thuret, Madame. Widow of the eminent French botanist. She bequeathed $40,000 to the French Republic for the promotion of agricultural science at Antibes.

Tobler, T. Occupied for several years in explorations in Palestine, he published numerous works upon its geology, architecture, etc. Born June 25th, 1806. Died January 21st, at Munich.

Valdez, Francisco Travossos. Member of the Portuguese mission to investigate the slave-trade in Timor. Author of "Six Years of a Traveller's Life in Western Africa."

Wahlgren, Professor Frederick. Of the University of Lund. Died in July, in his fifty-eighth year.

Weddell, Hugh d'Algernon. Born in 1819. Died July 22d, at Poitiers. Known for his "History of Cinchona Trees," and various works of South American plants.

Wilkes, Rear-Admiral Charles. Born in New York in 1801. Died in Washington, February 8th, at the age of nearly seventy-six. Distinguished in the American navy for professional ability and scientific acquirements; well-known as the commander of the famous American Exploring Expedition around the World, extending from August, 1838, to June, 1842. Commissioned as Rear-Admiral, on the retired list, July 25th, 1866.

Windich, T. One of the aborigines of West Australia, and the companion of Hunt, Alexander Foster, and John Forrest in their explorations. Died March 3d.

Winslow, Dr. Charles F. Author of many articles on physical science, relating more particularly to the phenomena of earthquakes. Died in Utah, at the age of sixty-six.

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SELECT WORKS ON SCIENCE PUBLISHED DURING 1877.

The usual list of works published during the year which the *Record* covers is here presented. As in past years, it is necessarily a very partial enumeration, and mostly confined to those works that have been noticed in a few of the prominent scientific periodicals of the day. The limitations of the *Record* preclude an exhaustive bibliography; nor, indeed, is this required by the plan of the work. Those volumes that have features of general interest to commend them, or are of special scientific value, have for the most part been included: two or three, however, have been mentioned that are of exceptional worthlessness, on account of their general circulation; in the latter case their character is indicated.

Wherever the volumes themselves were accessible, the titles and collations have been taken directly from them. In many cases, however, the compiler has been obliged to depend solely on the titles contained in the journals in which the volumes have been noticed, or upon booksellers' announcements. These are often, and indeed generally, deficient in some point or other: *e. g.*, the title may be imperfect or altered; the date of publication may be omitted, and then it is not always certain whether the volume has been published during the current year or in a past one; there is a difference in the statements as to sizes; the collation is frequently absent or erroneous, and the number of pages incorrectly given, and sometimes even the place of publication is omitted. Wherever the means of verification or correction by referring to the volumes themselves have been possible, they have been improved; unfortunately, however, in many cases the volumes themselves could not be consulted.

The titles of the works catalogued are enumerated in as nearly as possible a logical sequence, and under those heads where they would be most likely to be sought for by the

majority of persons. Two points, however, must be borne in mind: (1) the list of periodicals is by no means perfect; and (2) the annual records of the progress of science in the different departments are catalogued under the periodicals, immediately after the magazines, and not under the special sciences to which they relate.

The annual records have been thus classified together on account of their periodical nature, and for the convenience of librarians and others who may wish to procure the valuable epitomes of scientific literature which these represent. These volumes are generally not expensive, and most of them are very full in their notices of the literature of their respective subjects. They could readily be obtained by second and third rate libraries even, and would be of great use to the seeker after the most recent scientific facts; and yet the libraries that have even one of these valuable issues are extremely rare. It should be the duty of librarians to provide such complete summaries of scientific knowledge before almost anything else; but, as has been just indicated, the neglect to do so is very general. This neglect is probably due rather to the ignorance respecting the existence or value of such works than to any other cause; and it will probably be a surprise to many to know that such publications exist and have been long in the course of passage through the press.

Those journals have been referred to for the notices of books which are most generally accessible to ordinary readers on account of the nature of their circulation. They are:

(1.) The American Journal of Science and Art. Editors and Proprietors, James D. Dana, B. Silliman, and E. S. Dana (etc.). Third series. Vol. XIII.—(Whole number, CXIII.) Nos. 73–78, January to June, 1877 (et seq.). New Haven: Editors. 1877. (Published monthly, at $6 per annum.)

(2.) The American Naturalist: an Illustrated Magazine of Natural History. Edited by A. S. Packard, Jr. Associate Editors, Prof. G. L. Goodale, Department of Botany; Dr. R. H. Ward, Department of Microscopy. Volume XI. (et seq.). Boston: H. O. Houghton and Company. 1877 (et seq.). (Published monthly, at $4 per annum.)

(3.) Nature: a Weekly Illustrated Journal of Science. Volume XVI. May, 1877, to October, 1877 (et seq.). Lon-

don and New York: Macmillan and Co. 1877 (et seq.). (Published weekly.)

(4.) The Popular Science Monthly. Conducted by E. L. Youmans. Vol. X. November, 1876, to April, 1877 (et seq.). New York: D. Appleton and Company, 549 and 551 Broadway. 1877 (et seq.). (Published monthly, at $5 per annum.)

All the scientific works sent to the editor of the *Record* for enumeration have been heretofore and will hereafter be enumerated, whether specially noticed in the journals in question or not. The responses to the invitation for the transmission of copies to the editor for notice have been numerous, but many important publications have been withheld. In the interest of accuracy and completeness of enumeration, the editor renews his request for copies of new works for notice in future numbers of the *Record's* Bibliography.

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